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Kitchen of the Future

The economic and environmental benefits of protein diversification in Thailand

madre brava

Madre Brava is a global environmental advocacy organisation with a mission to achieve 100% sustainable, healthy, affordable food for all. We work with diverse groups in civil society, government and the food industry to achieve a food system that works for everyone.

The world requires a protein transition. Just as an energy transition has led a shift from fossil fuels to renewable energy, we now need to catalyse a protein transition to move the world from an over-reliance on animal-derived proteins to mostly plant-rich diets. This transition will lead to a rapid reduction in the numbers of livestock farmed – a mitigation strategy which a majority of scientists and experts working in this space agree is the only credible pathway to reduce emissions from food. In 2024, a study by Harvard Law School showed experts believed high income countries should reach 'peak meat' as soon as 2025.

A protein transition will have two key elements:

- **Overall protein consumption levels decrease in high- and mid-meat and seafood consumption countries** where consumption of protein is above recommended dietary levels.

- Production and consumption of proteins in these countries **shift away from beef, pork, chicken, seafood and dairy towards protein derived both from plants, legumes, and nuts and novel alternative protein products** (plant-based, fermented, and cultivated meat and dairy analogues).

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Creating change through investor-backed engagement

ARE's pioneering approach fills an engagement gap by bringing leading investors into dialogue with Asian-listed companies to address sustainable development and help companies align with investor priorities. Our high-quality independent research, robust investor and engagement expertise, provide corporate leaders and financial decision makers with insights leading to concrete action.

Our work focuses on thematic priorities to promote a sustainable and compassionate Asia. Our current programs and goals are:

Energy Transition: Credible transition pathways in alignment with the Paris Agreement.

Protein Transition: Transition pathways working towards our investor-aligned 2030 vision.

Founded in 2013, ARE maintains offices in Singapore and China, with a growing a presence in India and Japan.

Asia Protein Transition Platform

ARE launched the Asia Protein Transition Platform in December 2022, in collaboration with five founding investors representing USD 3 trillion in assets. The platform set a 2030 vision and goals for protein transition in Asia, along with investor expected disclosures for companies to move towards more responsible and sustainable proteins.

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CONTENTS

Photo: Anyasez

EXECUTIVE SUMMARY

> “Thailand has much to gain from a protein production system that is less reliant on animals as protein sources.”

Thailand is the top protein producer in Southeast Asia and the only net protein exporter in the whole of Asia. With its existing infrastructure, food manufacturing expertise and reputation as the ‘Kitchen of the World’, Thailand has the potential to become the global hub of sustainable proteins.

The country could reap the economic benefits that come from less reliance on imported raw materials, while creating new jobs and mitigating the impacts of industrialised animal agriculture, in particular a reduction in greenhouse gas emissions.

Relying on animals for protein means depending on imported raw materials for animal feed. These raw materials have seen price inflation in recent years and are linked to deforestation and nature depletion. Processing seafood is likely to become less profitable due to declining fishery yields and increasing fuel cost.[1] Thailand has much to gain from a protein production system that is less reliant on animals as protein sources.

This study, commissioned by Madre Brava and produced by Asia Research and Engagement (ARE), quantifies the benefits of a gradual and partial shift from animal to plant-based protein production in Thailand, as part of a broader ‘protein transition’. This report models the climate, land and economic impacts under the three scenarios: business as usual; 30% meat and seafood replacement by 2050; and a 50% replacement by 2050.

[1] https://www.krungsri.com/en/research/industry/industry-outlook/food-beverage/processed-seafood/io/processed-seafood-2023-2025

Thailand has a lot to gain if it replaces half of its meat and seafood production with plant-based proteins by 2050. According to our analysis, more than 60% of raw materials for animal feed (maize, wheat and soybeans) are not produced domestically, but imported. Reducing the number of farmed animals in Thailand's protein supply chain can have the following benefits:

Economy: Thailand could potentially create THB 1.3 trillion of economic value by reducing the amount of imported raw for protein production, whose prices have significantly inflated in recent years, and become more self-sufficient in the process.

Jobs: A protein diversification strategy for Thailand could create up to 1.15 million more jobs related to the production of protein sources in the country.

Climate: Moving protein production to 50% plant-based by 2050 would keep Thailand within emissions limits recommended by experts for climate safety, saving 35.5 million metric tonnes of CO2 emissions per year. That is the equivalent of removing 8.45 million cars from the road in the US.

Land: Switching 50% of protein production to plant-based protein could spare up to 2.17 million hectares of land in 2050 compared to the business-as-usual scenario, an area equivalent to the province of Nakhon Ratchasima.

How to make Thailand Asia's plant-rich food powerhouse

From the findings, we conclude that urgent interventions are needed to catalyze the growth of sustainable proteins in Thailand to replace 50% of animal protein with plant-based protein by 2050.

There are existing initiatives by the Thai government agencies to foster the growth of plant-based protein products,[2] which makes Thailand the most strategic country to kickstart the protein diversification and potentially create ripple effects throughout the region. To complement these promising initiatives, we recommend policy makers consider the following policy interventions:

Level the playing field between plant- and animal-protein: The government should explore taxation to incentivize sales and availability of plant-based foods to help Thai citizens make healthier and more sustainable choices.

2 'Reshape the Future' is a program by the Department of Industrial Promotion, an initiative to support small to medium-sized business owners by giving access to food technology and innovation to add value to their products. Another example is the latest foresight and 10-year roadmap by the Trade Policy and Strategy Office to make Thailand the hub of ingredients for sustainable and healthy foods along with six policy recommendations. Among these recommendations are to allocate resources for research and development of plant-based products, and to expand both the domestic and international market for plant-based foods.

Public procurement and sourcing: Serve plant-rich meals in government-led functions and conferences to generate demand for plant-based products.[3] Government offices can also consider offering more plant-rich options in the canteens of public administration buildings and offices, public schools and hospitals.

Adopt a just transition plan: Develop pathways including financial support and capacity-building programs for Thai farmers to switch to crop production for plant-based proteins.

The private sector can play a crucial role in consumers' ability to access sustainable proteins. We have the following recommendations for supermarket chains, big restaurant chains, food service, and food manufacturers:

For supermarkets

Set targets to increase the sales and share of sustainable proteins and put in place measures to meet these including:

- Lowering the price of plant-based products to match those of animal protein to remove the affordability barrier and support consumer access to healthier and more sustainable foods.
- Displaying plant-based products more prominently alongside animal protein to encourage purchase and improve visibility.
- Complementing the more prominent display with materials for consumers about preparation, nutritional content, and health benefits of plant-based products.

For food manufacturers

- Incorporate a protein diversification strategy into wider emissions reduction and sustainability plans such as Net Zero pledges.
- Invest in research and development to make alternative protein products tastier, less processed, more nutritious and more affordable, with a view to cater for both exports as well as the domestic market.

For food service companies

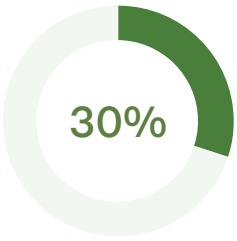
- Increase the offering of plant-based items and display the options alongside the regular menus.
- Plant-based options should be offered at the same price range as regular menus and not at a premium.

[3] 'An example of this initiative is MEHSI and NXPO's initiative to boost plant-based foods sales in Thailand by offering at least 30% plant-based food in corporate events and meetings. https://www.nxpo.or.th/th/en/27408/

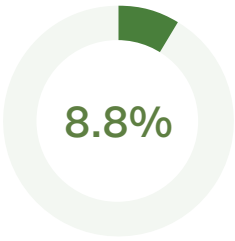
INTRODUCTION

Photo: Cottonbro Studio

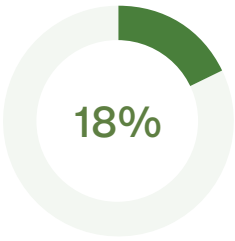
In
2022
Agriculture contributed



country's total labour force



Gross Domestic Product (GDP)



export value

Thailand is a major food producer and exporter, with a significant portion of its economy and workforce dedicated to crop and livestock production. In 2022, agriculture contributed to 30% of the country's total labour force,[4] 8.8% of Gross Domestic Product (GDP)[5], and 18% of export value.[6] [7]

Among Thailand's top food exports are chicken, shrimp, and tuna,[8] which have been focus areas for development. These commodities also play an important role in the diets of Thai residents: meat consumption per capita has seen a 71% increase from 16.6kg in 1990 to 28.1kg in 2022, seafood consumption per capita has not exhibited the same growth but remains significant at 32.4 kg in 2022.[9]

4 https://www.ilo.org/publications/working-and-employment-conditions-agriculture-sector-thailand-survey
5 https://www.statista.com/statistics/331893/share-of-economic-sectors-in-the-gdp-in-thailand/
6 https://data.worldbank.org/indicator/TX.VAL.AGRI.ZS.UN?locations=TH
7 https://data.worldbank.org/indicator/TX.VAL.FOOD.ZS.UN?locations=TH
8 https://www.statista.com/statistics/1302120/thailand-foodstuff-exports-by-category/
9 OECD-FAO Agricultural Outlook 2023-2032

However, sustaining growth in the production of these commodities presents several challenges. Livestock production depends heavily on imported maize and soy for animal feed. These feed crops' prices have significantly inflated in recent years. The shrimp industry also faced repeated setbacks from disease outbreaks and growing competition from rival producers.[10] Processed seafood production struggles with declining local fishery yields and the industry suffers eroding profit margins due to the need to import raw materials.

In addition to these challenges, the livestock and seafood industries are now being tested on how they can manage further growth without worsening their environmental and social impacts. Deforestation and soil degradation from expansion of crop cultivation hinders the nation's efforts towards increasing forest cover.[11] Rising greenhouse gas emissions also works against progress towards the net zero target.[12]

> **"Livestock production depends on increasingly expensive imported maize and soy for animal feed."**

The Thai government has shown intent to actively guide and support these industries in their transformation towards just and sustainable systems. In 2021, Bio-Circular-Green (BCG) economy was announced as a component of the national strategy to pursue future economic development, placing an emphasis on developing high-value products and services that are eco-friendly and require fewer resources.[13] The food and agriculture sector was identified as one of four strategic sectors. This is aligned with the actively promoted concept of "Future Food", representing the government's intent to transform Thailand into a global hub for sustainable, innovative, and high-value food.[14]

[10] https://www.nationthailand.com/blogs/business/40012418
[11] https://www.un.org/esa/forests/wp-content/uploads/2019/12/Thailand.pdf
[12] https://climatepromise.undp.org/what-we-do/where-we-work/thailand
[13] https://www.bcg.in.th/eng/background/
[14] https://www.nationthailand.com/thailand/economy/40028686

Photo: Michael Sawyer

> “If produced at scale to replace conventional animal proteins, plant-based proteins will have an outsized impact for mitigation.”

Alternative proteins, as opposed to conventional animal proteins, are one of several categories within the Future Food industry, and currently contribute to 4.6% of Future Food export value (THB 6.4 billion).[15] Alternative proteins, particularly plant-based proteins, have tremendous potential for boosting Thai exports while mitigating the negative impacts of protein production. If produced at scale to replace conventional animal proteins, plant-based proteins will have an outsized impact for mitigation.

This report aims to quantitatively evaluate the ongoing and potential impacts of scaling up plant-based proteins within Thailand’s meat and seafood sector. Potential impacts will be projected across three aspects: land-use, greenhouse gas emissions, and economic activity, in these three scenarios:

1 *Business-as-usual:* Meat and seafood production is entirely supplied by animal proteins.

2 *30% by 2050:* Plant-based proteins contribute to 30% of total production in 2050.

3 *50% by 2050:* Plant-based proteins contribute to 50% of total production in 2050.

[15] https://www.bangkokpost.com/business/general/2784844/country-aims-for-2-5-growth-in-future-food-exports

PROJECTIONS FOR MEAT AND SEAFOOD PRODUCTION

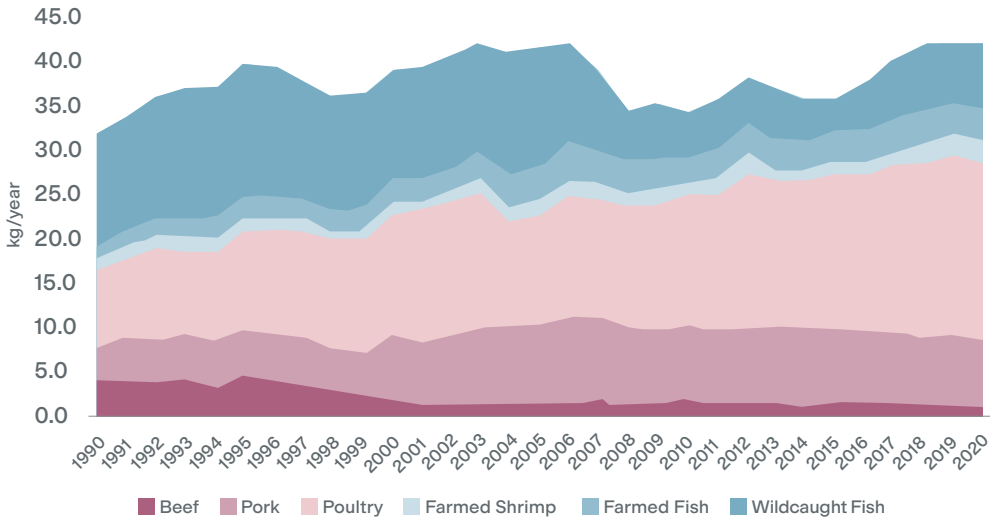
Photo: Mikhail Preobrazhenskiy

The three scenarios will contain identical projections for the levels of consumption, exports and thereby production, differing only in the ratio of animal proteins to plant-based proteins. Note that from here on, the volumes for each protein commodity are presented in terms of the fully dressed, offal-free, and bone-free format, which would differ from other numbers presented as live weight or carcass weight.

Domestic Consumption

Considering past trends in dietary changes, Thailand's projected age demographics, urbanization rate, and income growth,[16] the graphs below illustrate the projected per capita (Figure 1) and total consumption for meat[17] and seafood[18] (Figure 2) through to 2050.

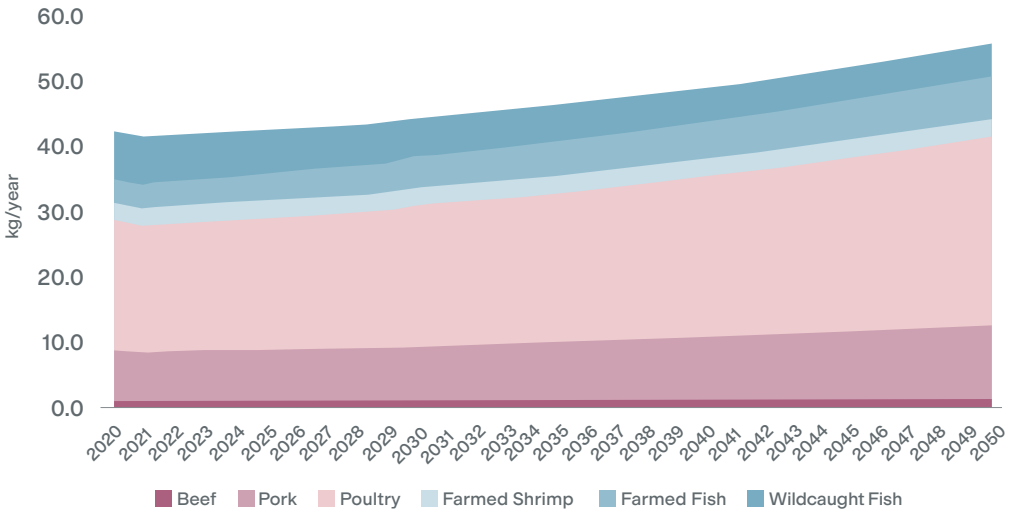
Figure 1: Per capita consumption of meat and seafood in Thailand in 1990-2020, by protein type.



Source: OECD-FAO, USDA, ARE analysis

[16] See annex for projections on age demographics, urbanization rate, and income growth.
[17] Mutton was not included within the scope.
[18] Molluscs and crustaceans (aside from shrimp) were not included within the scope.

Figure 2: Projected per capita consumption of meat and seafood in Thailand in 2020-2050, by protein type.



Source: OECD-FAO, USDA, ARE analysis

Figure 2 demonstrates a long-term trend in increasing meat consumption per capita. This is projected to increase from 28.1 kg in 2020 to 41.6 kg in 2050. Poultry is responsible for most of the past growth and is expected to account for most of the future increase if there is no intervention. Pork has the second highest share of growth, while beef consumption per capita is not expected to change significantly.

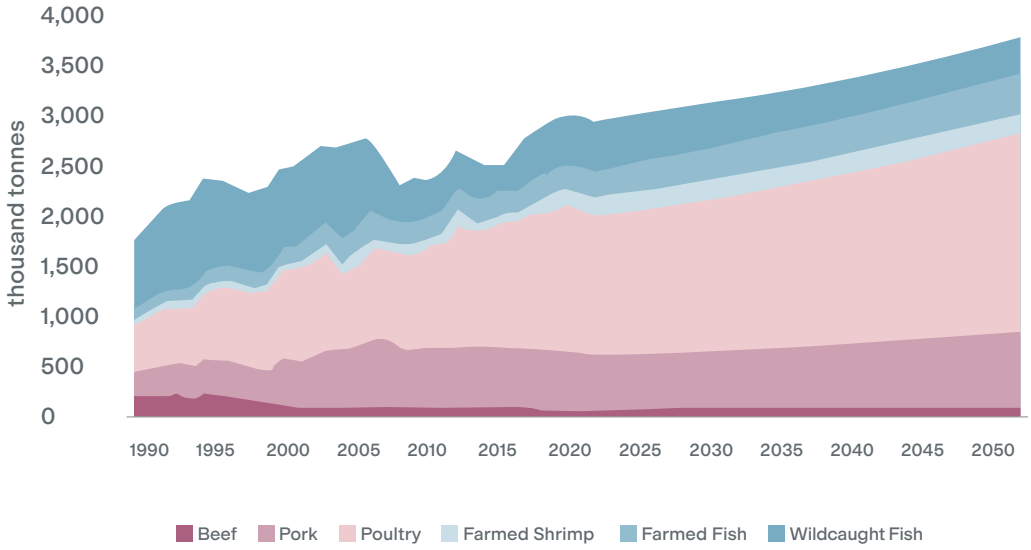
Seafood consumption per capita remained stable for decades and is expected to remain consistent. However, within the seafood segment, the consumption of wild-caught fish is expected to continue to decline due to depleting natural resources. This is currently offset by an increase in the consumption of farmed fish consistent with global trends.[19]

Overall meat and seafood consumption per capita will increase from 41.9kg in 2020 to 55.1kg in 2050. Without intervention, this increasing demand will be served by increased production and expansion of intensive livestock and aquaculture systems in and beyond Thailand.

Figure 3 shows that the projections for total consumption mostly follow the projections for Thai consumption per capita but with a gentler gradient due to an expected decline in population size from 72 million to 68 million at 2050.[20]

[19] https://research.wri.org/sites/default/files/2019-07/F_REP_Food_Course4_web.pdf
[20] https://databank.worldbank.org/source/population-estimates-and-projections

Figure 3: Total consumption of meat and seafood in Thailand in 1990-2050, by protein type.

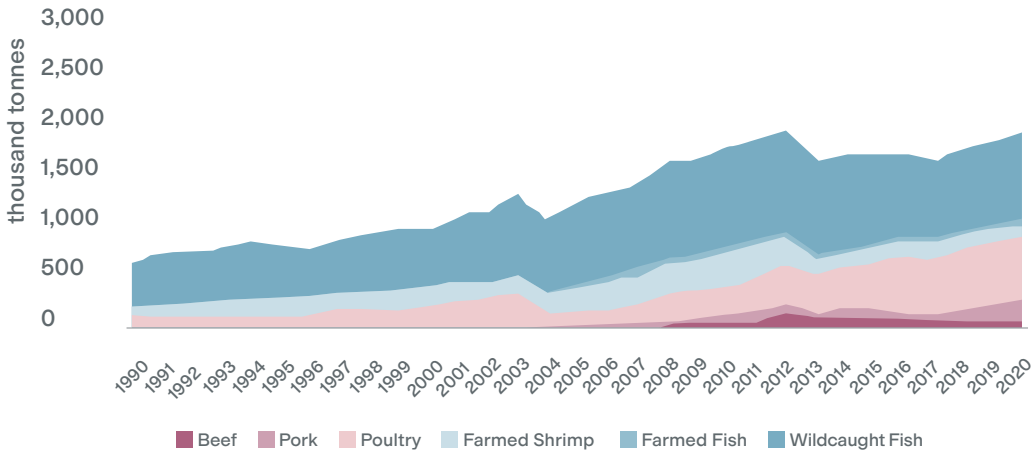


Source: OECD-FAO, USDA, World Bank, ARE analysis

Exports

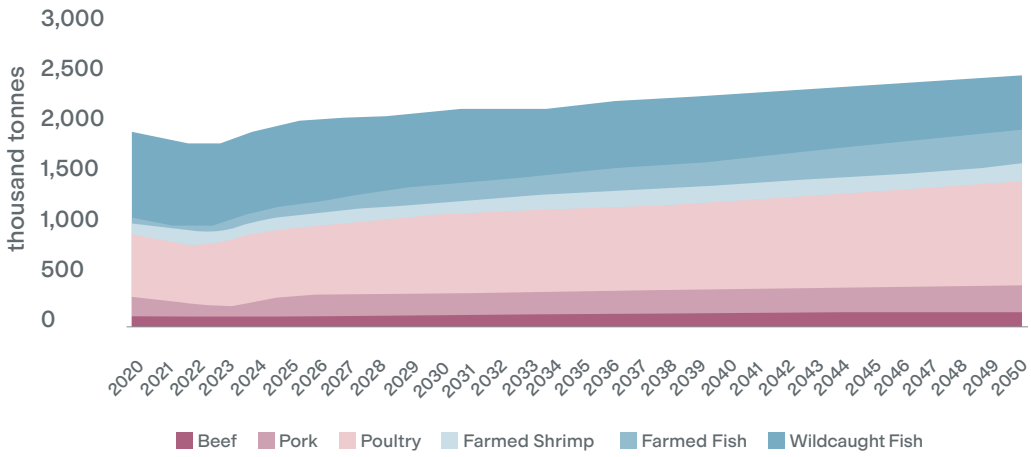
Projections for exports were based on consideration of each commodity's competitive landscape and regional/global demand. Figures 4 and 5 illustrate the historical and projected volumes respectively of meat and seafood export through to 2050.

Figure 4: Total exports of meat and seafood from Thailand in 1990-2020, by protein type.



Source: OECD-FAO, USDA, ARE analysis

Figure 5: Total exports of meat and seafood from Thailand in 2020-2050, by protein type.



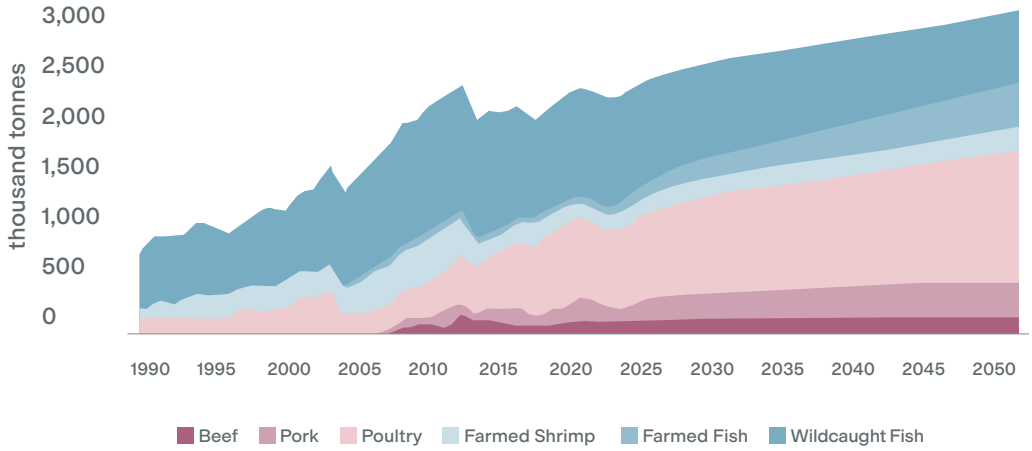
Source: OECD-FAO, USDA, ARE analysis

Poultry exports are expected to grow the fastest, supported by an expected increase in regional and global demand[21] —we project 1.5% growth annually. Pork exports are expected to gradually recover to pre-African Swine Fever (ASF) levels[22] then grow steadily but at a slower rate than poultry. Shrimp exports will remain competitive but face pressure from rivals, with disease outbreaks such as Early Mortality Syndrome (EMS) proving a persistent challenge.[23] We projected the growth rate for pork and shrimp exports at 1.0% annually.

Wild-caught fish exports, particularly canned tuna, struggle with tightening margins due to declining local fishery yields. As Thailand's fishing fleet faces ongoing declines in fishery yields, we projected that the exports of wild-caught fish exports will decline steadily at 1.5% annually. To maintain the same quantity of fish exports, the decline in wild-caught fish exports will theoretically be compensated with farmed fish exports supplied by increasing both production and imports of farmed fish. All the above assumptions are integrated as per the total export projections to 2050 in Figure 6.

[21] https://www.euromonitor.com/global-market-overview-of-chicken/report
[22] https://www.kasikornresearch.com/en/analysis/k-social-media/Pages/Pig-Price-FB-18-08-2023.aspx
[23] https://www.krungsri.com/en/research/industry/industry-outlook/food-beverage/processed-seafood/io/processed-seafood-2023-2025

Figure 6: Total exports of meat and seafood from Thailand in 1990-2050, by protein type.

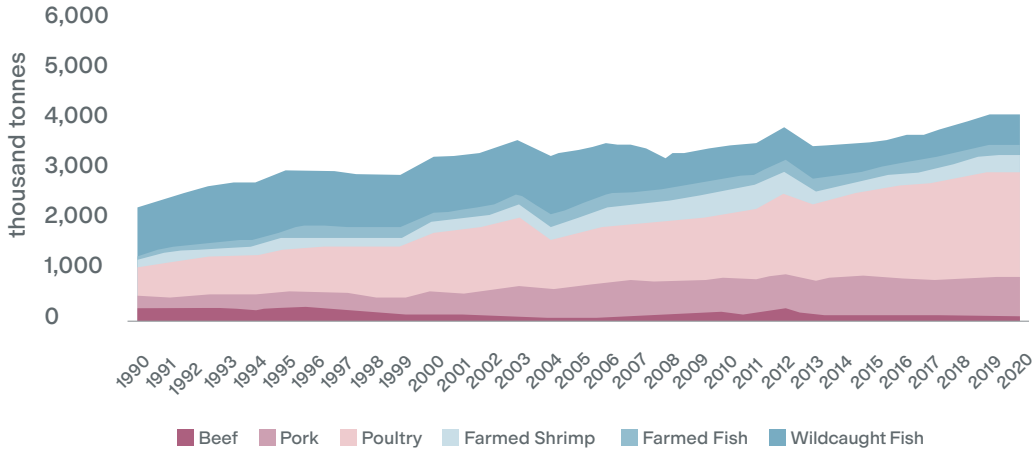


Source: OECD-FAO, USDA, ARE analysis

Production

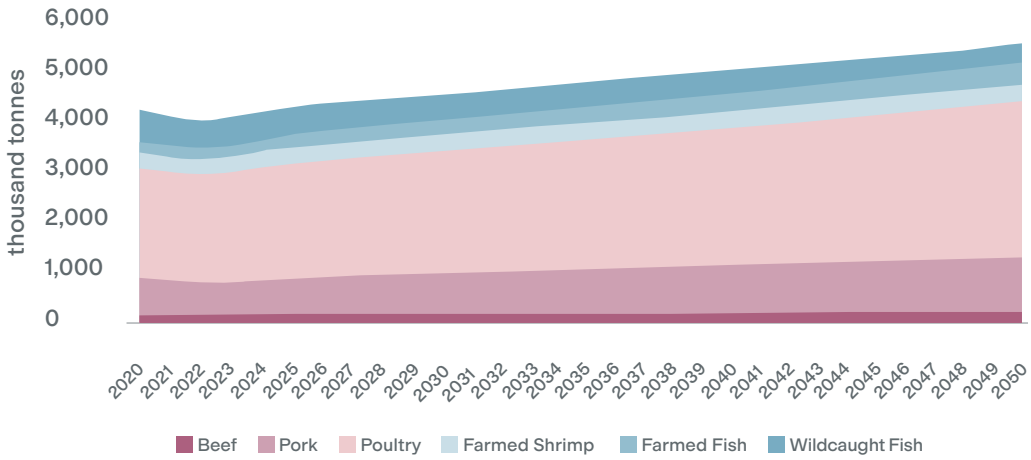
Projections for production volumes are the sum of the projected consumption and net exports. Figures 7 and 8 show the historical and projected volumes of meat and seafood production through to 2020 and 2050.

Figure 7: Total production of meat and seafood in Thailand in 1990-2020, by protein type.



Source: OECD-FAO, USDA, ARE analysis

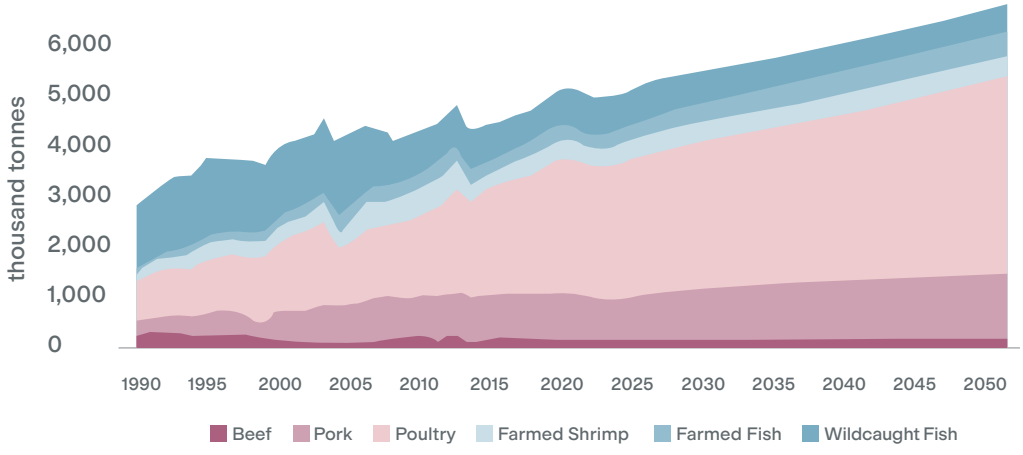
Figure 8: Total production of meat and seafood in Thailand in 2020-2050, by protein type.



Source: OECD-FAO, USDA, ARE analysis

Summarising the projections for production volumes, overall meat and seafood production will increase from 3.9 million tonnes to 5.1 million tonnes with the greatest growth driven by the poultry followed by pork sector. Wild caught seafood production is projected to stagnate, and increased aquaculture production will gradually compensate for declining fishery production.

Figure 9: Total production of meat and seafood in Thailand in 1990-2050, by protein type.

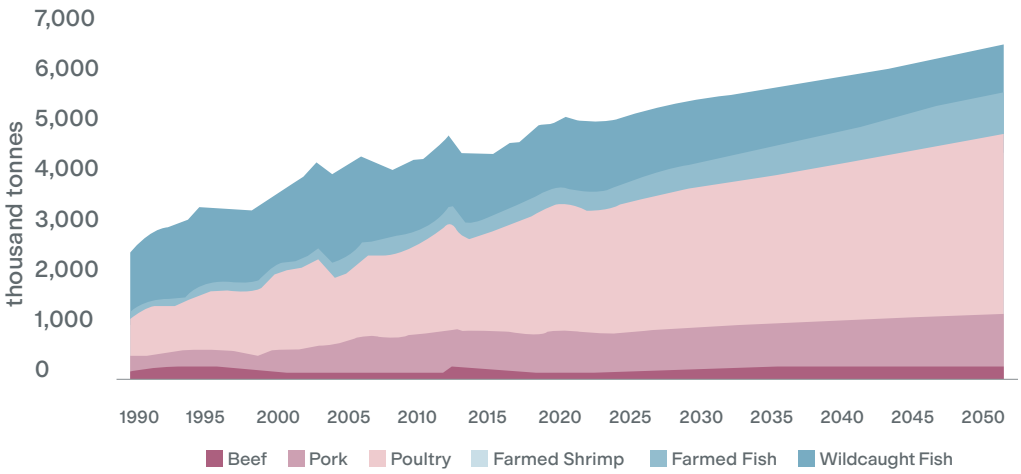


Source: OECD-FAO, USDA, ARE analysis

Total Demand

Figure 10 shows the total demand for meat and seafood products, as defined by the aggregate of domestic consumption and exports.

Figure 10: Total demand of meat and seafood in Thailand in 1990-2050, by protein type.



Source: OECD-FAO, USDA, ARE analysis

Total demand for meat and seafood products in Thailand grew from 2,350 thousand tonnes in 1990 to 4,835 thousand tonnes in 2020 and is projected to rise to 6,134 thousand tonnes in 2050. Of the total 6.1 million tonnes demand, 5.1 million tonnes is expected to be produced locally while the remaining 1 million tonne would be sourced through import—mostly for wild-caught and farmed fish.

Total demand for meat and seafood	In 1990 2,350 thousand tonnes	In 2020 4,835 thousand tonnes
In 2050 Project to rise to	6,134 thousand tonnes	

Photo: Sergio Souza

LAND-USE AND LAND-USE CHANGE

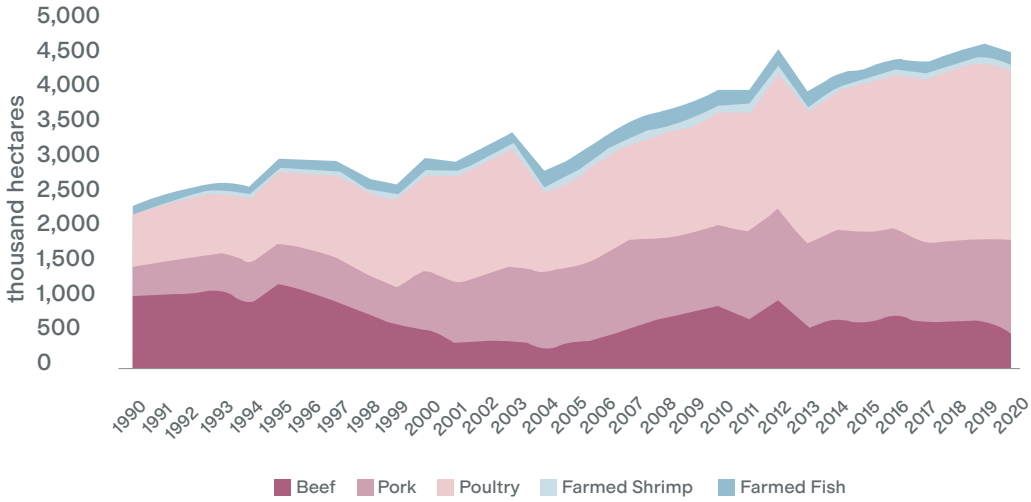
Thailand has 17.2 million hectares of arable land which is 33.6% of its total land area.[24] The main crop produced is rice, which takes up almost half the total cultivated area, followed by sugarcane, cassava, and maize. To estimate the land area used to support meat and seafood production, we attribute the size of harvested area for maize and rice based on the proportion of production that goes towards animal feed. In 2020, that would be 1.15 million hectares and 1.03 million hectares from maize and rice respectively.

Animal feed raw materials to support Thailand's meat and seafood production

However, due to the imports of animal feed raw materials, the actual land area supporting these industries, on a global basis, is much larger. In 2020, 4.8 million tonnes of maize and 1.9 million tonnes of rice was produced locally in Thailand. In addition, the sector had to import another 1.9 million tonnes of maize, 2.3 million tonnes of wheat, 630 thousand tonnes of distiller's dry grains, and 3.8 million tonnes of soybean. *These raw materials add up to 16.8 million tonnes in weight, of which just 6.7 million tonnes (less than 40%) is produced locally.*

[24] https://data.worldbank.org/indicator/AG.LND.ARBL.HA?locations=TH

Figure 11: Land-use area for Thailand's meat and seafood production, by protein type.



Source: ARE analysis

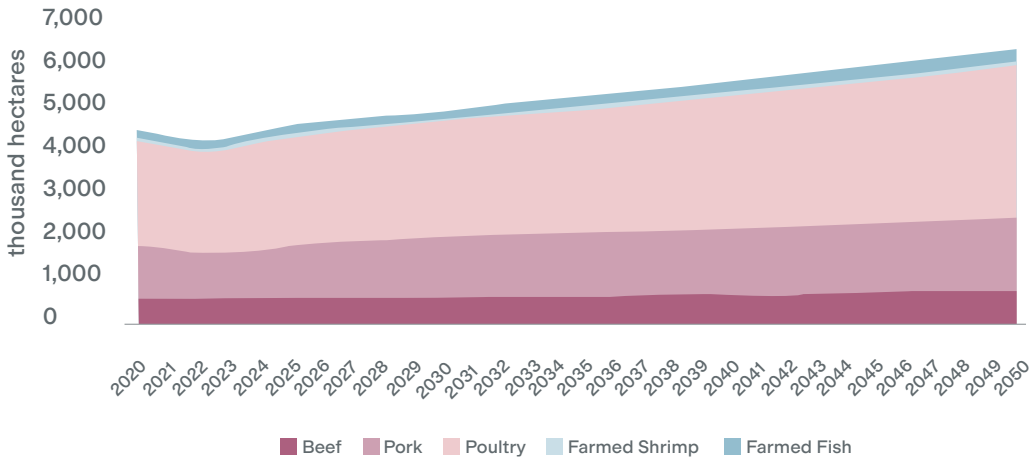
Using land-use intensity estimates from Poore and Nemecek (2018)[25] combined with Thailand's historical production volumes, allows us to estimate the total land-use associated with Thailand's meat and farmed seafood production as 4.3 million hectares in 2020, as shown in Figure 11. This is 95% higher than the 2.18 million hectares of land-use in 1990.

This reflects the dramatic increase in Thailand's animal meat production since 1990. The 180% rise in overall meat consumption and exports led to an almost doubling in total land-use, despite a shift from beef towards pork and poultry which is generally less land-intensive per kilogramme.

We then estimate that land-use for protein production in the BAU scenario will grow to 6.15 million hectares in 2050, a 42% increase from 2020, as shown in figure 12.

[25] https://doi.org/10.1126/science.aaq0216

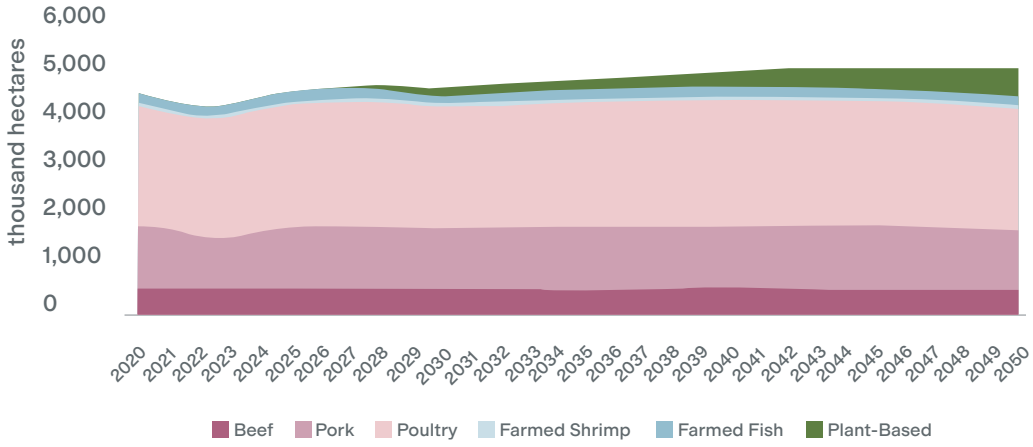
Figure 12: Projected land-use area for Thailand's meat and seafood production in BAU scenario, by protein type.



Source: ARE analysis

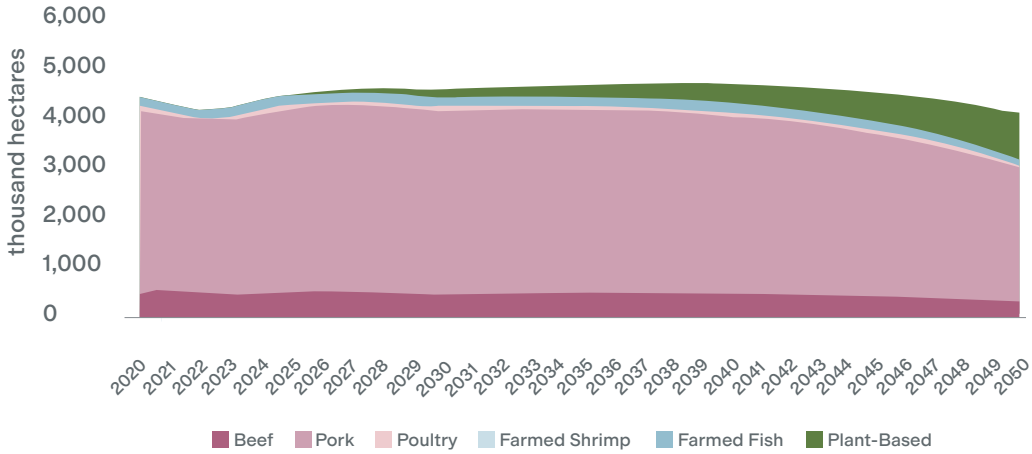
Whereas in the 30%/50% by 2050 scenarios as shown in figures 13 and 14, the total land-use would be 4.85 million hectares (13.5% increase from 2020) and 3.98 million hectares (6.9% decrease from 2020) respectively, representing a marked improvement of 1.30 million hectares and 2.17 million hectares from the 6.15 million hectares projected in the BAU scenario.

Figure 13: Projected land-use area for Thailand's meat and seafood production in 30% by 2050 scenario, by protein type.



Source: ARE analysis

Figure 14: Projected land-use area for Thailand's meat and seafood production in 50% by 2050 scenario, by protein type.



Source: ARE analysis

It may be a surprise that the plant-based diversification scenarios do not lead to greater reduction in land-use in comparison to 2020. This is partially explained by the increase in overall production volume, but also because these scenarios include some substitution of wild caught fish with plant-based proteins, which despite having a lower land-use intensity than animal meat and farmed fish, is still more land-intensive than farmed shrimp and wild caught fish.

Deforestation and Land-Use Change

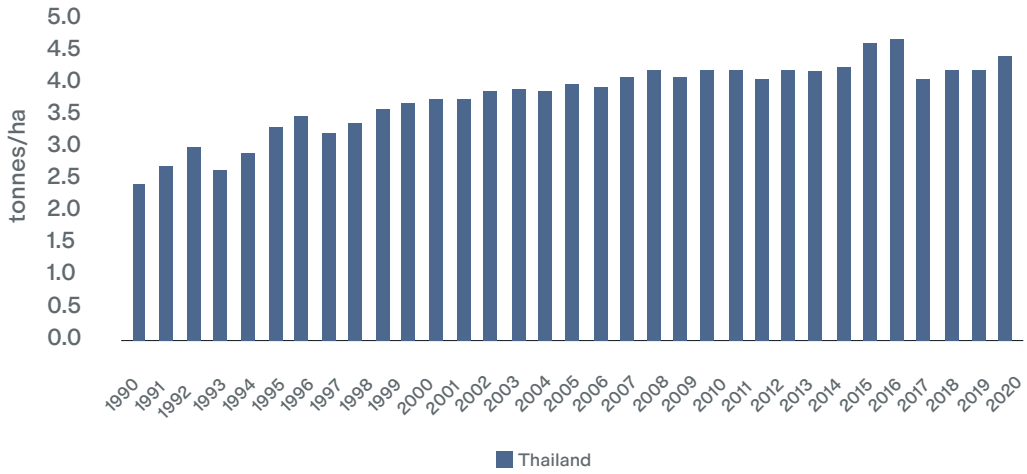
An increase in land area required naturally leads to deforestation and land-use change to meet the production volume required. Proponents of sustainable intensification point out that increases in crop yields may allow the system to produce more using the same area of land. We explored how this assertion stacks up historically and in future forecasts.

Historically, increasing crop yields (per unit of harvested area) have not been enough to avoid deforestation. In 2014, the Thai Feed Mill Association cited data from the Thai Land Development Department that as much as 47% of maize cultivation area in Thailand was in forest territory.[26] Previous research found that 11.6 million rai (1.9 million hectares) of forest in the Mekong Basin was converted for maize cultivation between 2015 and 2023.[27] A World Resources Institute (WRI) report in 2020 estimated that 8.2 million hectares of deforestation in South America, where Thailand sources over 90% of its soybeans from, was driven by soybean cultivation between 2000-2015.[28]

[26] https://ap.fftc.org.tw/article/1354
[27] https://www.greenpeace.org/thailand/publication/28381/food-gms-forest-maize-haze-2023/
[28] https://www.wri.org/research/estimating-role-seven-commodities-agriculture-linked-deforestation-oil-palm-soy-cattle

It is not certain that existing or new crop cultivars can maintain the steady upward trend in historically exhibited yields. Figure 15 shows the yield for maize production in Thailand, and Figure 16 shows the yields for soybean production in Brazil and the United States.

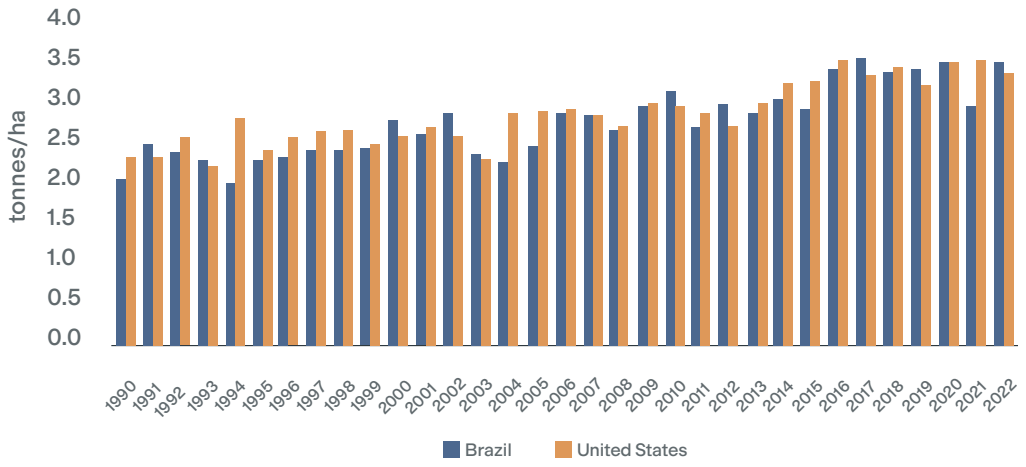
Figure 15: Yields for maize production in Thailand



Source: OECD-FAO

Maize yields rapidly increased over 15 years by 59%—from 2.41 tonne/ha in 1990 to 3.83 tonne/ha in 2005. But the yields increased only 9% in the next 15 years to reach 4.18 tonne/ha in 2020. An indication that maize yields could be near a practical ceiling, given that most of the maize cultivation area is in upland forest area where formal irrigation development is prohibited.[29]

Figure 16: Yields for soybean production in Brazil and the United States



Source: OECD-FAO

[29] https://ap.fftc.org.tw/article/1354

Growth in soybean yields is depicted in figure 16. It has not plateaued in the same way and has experienced a stepped improvement from 2015. However, OECD-FAO Agricultural Outlook (2023-2032) had forecast for soybean yields in Brazil and United States to increase by only 2.3% and 4.9% respectively in 10 years from 2020 to 2030.[30]

Climate change creates multiple challenges to improving and maintaining crop yields: rising temperatures, changes in precipitation patterns, soil degradation, and extreme weather events. Research shows that climate change hinders crop yields ranging from 7% to 23% without adaptation.[31] The same study found that adverse effects are more likely in areas of lower latitudes, which signals yet another warning to Thailand's maize supply. There are also various Thai studies that project negative yield and economic impacts for maize and rice crops under scenarios of rising temperatures.[32]

Even with the assumption of stable crop yields, the estimated additional 1.87 million hectares[33] of land-use required in the BAU scenario would be a conservative estimate for the scale of associated deforestation. This is because taking the difference between these two static points does not account for the dynamics of land-use changes that occur throughout the period. Intensive farming methods leads to rapid degradation of the land's productive capacity, which drives producers to clear more forests to achieve the same crop yields. This continuous clearing of forests and subsequent abandonment of infertile land means that the actual forest area deforested throughout the 30-year period would need to be much greater to achieve 6.1 million hectares of arable land in 2050. A study on tropical deforestation found that 35%-55% of land deforested in 2010-2014 was left unused,[34] citing abandoned agricultural land, unintended forest fires (from agricultural burning), speculative clearing, and land tenure issues as key drivers.

In summary, the analysis projects that the additional land area required to support Thailand's meat and seafood sector in 2050 is 1.87 million hectares in the BAU scenario, as compared to 2020. Moderate plant-based diversification in the 30% by 2050 scenario requires 1.30 million hectares less than the BAU scenario in 2050 but still requires 576 thousand hectares in addition to 2020. Further diversification in the 50% by 2050 scenario requires 2.17 million hectares of land less than the BAU scenario and could free up 293 thousand hectares of land compared to today's use.

[30] Refer to annex
[31] https://www.nature.com/articles/s43017-023-00491-0
[32] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8986419/
https://dicf.unepgrid.ch/thailand/climate-change
https://mpra.ub.uni-muenchen.de/118290/1/Attavanich%20%282017%29.pdf
[33] 4.3 million hectares in 2020 vs 6.1 million hectares in 2050
[34] https://www.science.org/doi/10.1126/science.abm9267

Discussion

Avoidance of further deforestation and land use change is the most effective ambition and helps avoid substantial climate emissions and biodiversity loss. Given the complexity of primary forest, reforestation is a very secondary or additional approach with land conservation. Clearly the 50% plant-based protein scenario is most protective, avoiding substantial further land use change and related emissions, especially considering the inherent underestimation of land use by 2050 with a BAU scenario.

In addition to a policy approach needed to avoid further land use change, the 20-Year Thai National Strategic Plan (2018-2037)[35] called for restoring 7.8 million hectares of forest cover (natural and economic). This is an ambitious and commendable target but much more land use prevention policy and financial support needs to be given to the stakeholders who can effect these changes. The Economic Forest Plantation Project and the Tree Bank system[36] showed that smallholders can create a sizeable impact on forest restoration, but these policies need to be designed and tweaked continuously through consultation with these groups.

Given the impending risks presented by climate change, it is highly unlikely that continuous improvement in crop yields would be sufficient to meet the projected increase in demand. It is again noted that the additional land area required by 2050 is an underestimate of potential deforestation due to the continuous degradation of fertile land.

We recommend that the meat and seafood sector pursue rapid and wide-scale plant-based diversification so that the increase in demand can be met while minimising associated deforestation and land-use change locally and beyond Thailand. Crop diversification i.e. direct cropping or intercropping with soy or mung bean, as advocated with rice and other staple crops, is further shown to enhance climate, water footprint, and farm household resilience in Thailand, adding to the mid- and long-term opportunity and value of a substantial plant-based protein scenario.[37]

[35] https://policy.asiapacificenergy.org/node/4535
[36] https://www.recoftc.org/stories/forest-restoration-requires-smallholders-and-their-access-safe-and-fair-financing
[37] https://link.springer.com/article/10.1007/s10584-024-03732-3
https://www.sciencedirect.com/science/article/abs/pii/S0048969721058198

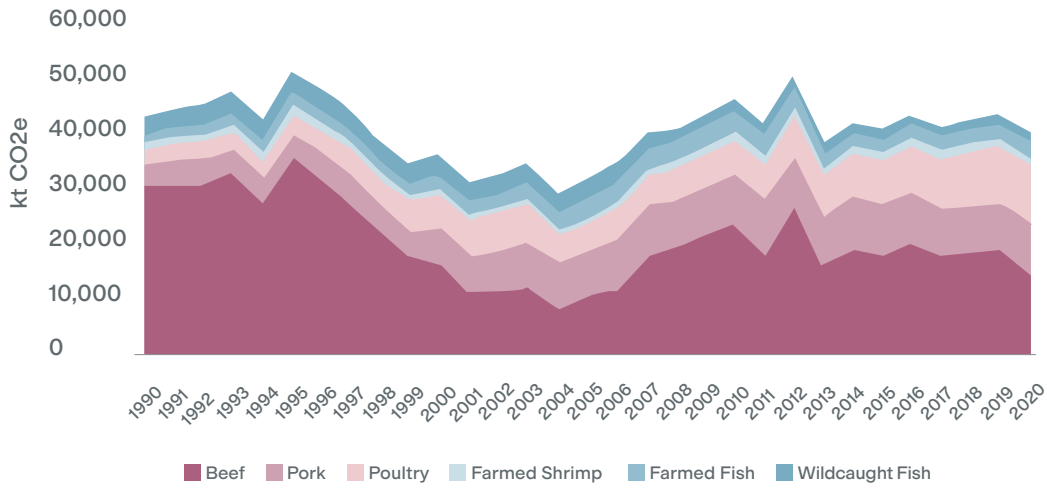
GREENHOUSE GAS EMISSIONS

Photo: Blaque X

Rice often dominates the discussion when it comes to reducing greenhouse gas emissions from the agricultural sector, rightly so, since rice production contributes to 51% of Thailand's direct emissions from agriculture, and with a high proportion of methane.[38] However, Thailand's meat and seafood sector could be a more significant source of GHG emissions when accounting for both direct and indirect emissions.

We estimated the lifecycle emissions from meat and seafood production in Thailand, using GHG emission intensity figures from the FAO GLEAM v3.0 database which is subregion-specific,[39] producing figure 17.

Figure 17: GHG emissions from Thailand's meat and seafood production, by protein type (1990-2020).



Source: ARE analysis

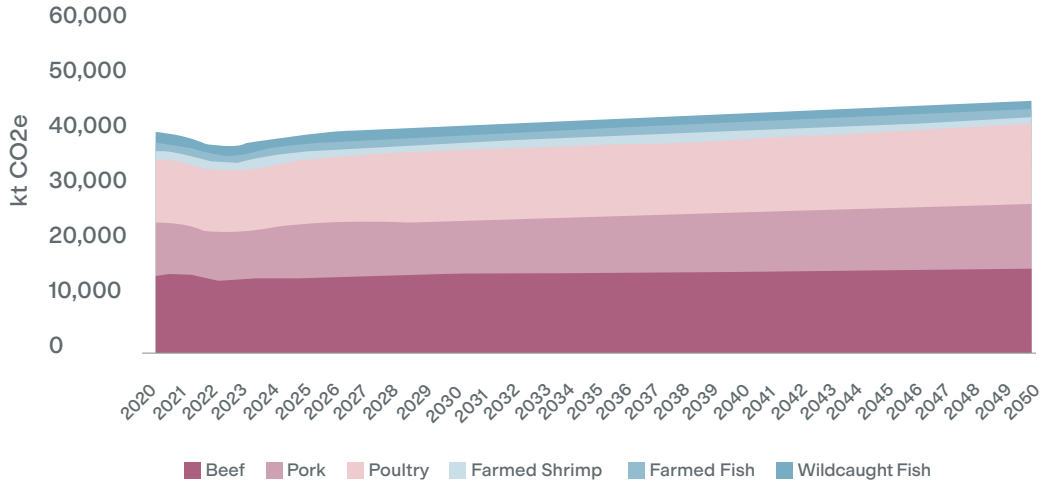
[38] https://www.ccacoalition.org/sites/default/files/resources/2021_Thailand-Country%20Report-Scoping-Study_CCAC.pdf

[39] In this case, GHG emissions intensities are aggregated for Southeast Asia.

It is estimated that there was a slight reduction in GHG emissions from meat and seafood production, from 41.8 Mt CO2e in 1990 to 39.1 Mt CO2e in 2020. A decrease in total emissions despite a drastic increase in overall meat production is surprising, and mainly results from the reduction in the levels of GHG-intensive beef production.

Since beef production is not projected to decline further, the GHG emissions from meat and farmed seafood production through 2020-2050 is expected to increase with overall demand, as shown in Figure 18.

Figure 18: Projected GHG emissions from Thailand's meat and seafood production in the BAU scenario, by protein type (2020-2050).



Source: ARE analysis

In the BAU scenario, total GHG emissions are expected to increase 14.7% from 39.1 Mt CO2e in 2020 to 44.9 Mt CO2e in 2050.
14.7% may seem like a moderate increase in GHG emissions given the larger production volume projected for 2050. This is because, given Thailand's essentially intensified animal production industry, we assume that additional demand in the BAU scenario will be met by industrial animal production that is generally less emissions intensive. We also assumed that the sector would be able to implement some efficiency improvements that result in an annual reduction of 0.5% in emissions intensities. Despite these assumptions and additional concerns of physical climate impacts (not calculated), the total GHG emissions in a BAU scenario greatly exceed the climate-safety threshold.

Climate-Safety Threshold

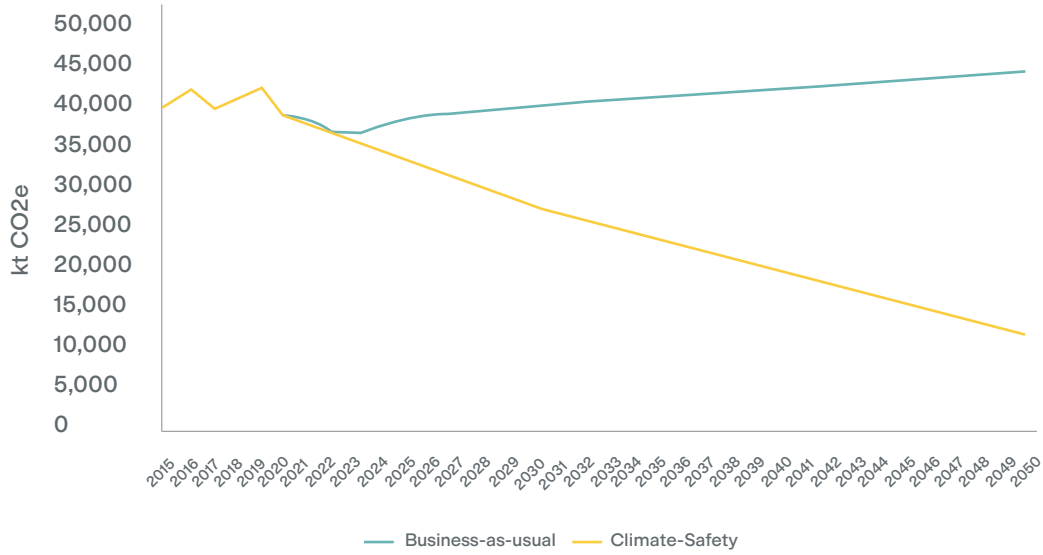
In 2022, the Science-Based Targets Initiative (SBTi) released its Food, Land and Agriculture (FLAG) guidance[40] to guide the food-agri industry towards a "climate-safe scenario." Key takeaways from the FLAG guidance, below, include requirements for validation of net-zero targets.

1. Deforestation needs to be eliminated from the supply chain by 2025.
2. GHG emissions reduction of at least 72% by 2050 from base-year levels.

The FLAG guidance also offered short-term targets for annual percentage reduction in emissions intensity for each commodity through to 2030.[41]

We used 2020 as the base-year for emissions reduction, 2030 as the target year for eliminating deforestation,[42] and the short-term emissions intensity reduction targets as they were provided by SBTi, to estimate the decarbonisation pathway required for climate-safety, as shown in figure 19.

Figure 19: Projected GHG emissions from Thailand's meat and seafood production in BAU scenario (2020 to 2050), and the threshold for climate-safety.



Source: ARE analysis

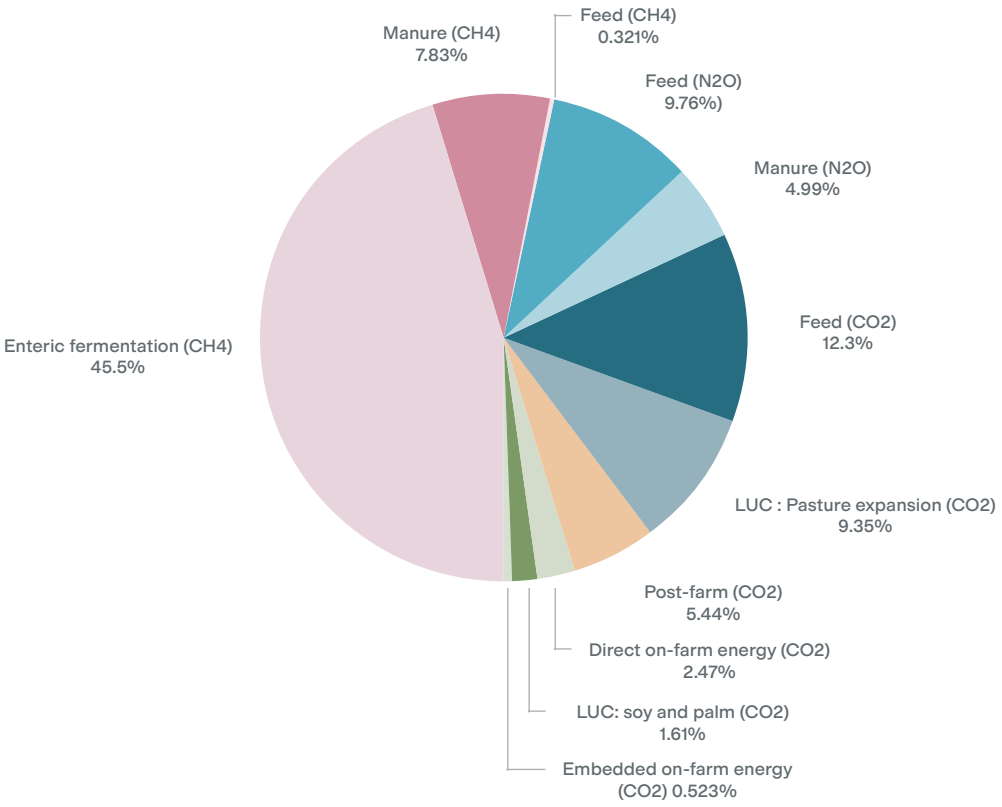
[40] https://sciencebasedtargets.org/sectors/forest-land-and-agriculture
[41] Please refer to the annex for these annual percentage reduction targets
[42] We acknowledge that this deviates from SBTI's requirement for 2025 as the target year but decided on 2030 as an aspirational and feasible target for Asian markets, and aligned with the Glasgow Declaration to which Thailand committed in 2022. https://bkktribune.com/thailand-to-take-part-in-the-global-forest-and-land-use-protection-declaration-almost-five-month-delay-in-action/

We can observe that the GHG emissions in the BAU scenario are in line with the climate-safety threshold up to 2022 (due to a drop in production volume) before exceeding the threshold. *At 2050, the 44.9 Mt CO2e projected in the BAU scenario, is over four times that of an SBTi informed climate-safety threshold, 11.0 Mt CO2e.*

Emissions Sources and Potential Mitigation

The lifecycle emissions of meat and seafood products are distributed across their value chains, so attempted mitigation currently involves a variety of strategies targeting different stages of the production process. Commonly discussed mitigation measures are manure management through anaerobic digesters, reducing ruminant methane production through feed additives, genetic selection for improved feed efficiency, alternative feed protein sources and various sources of renewable energy etc.

Figure 20: GHG emissions from global livestock production, by source

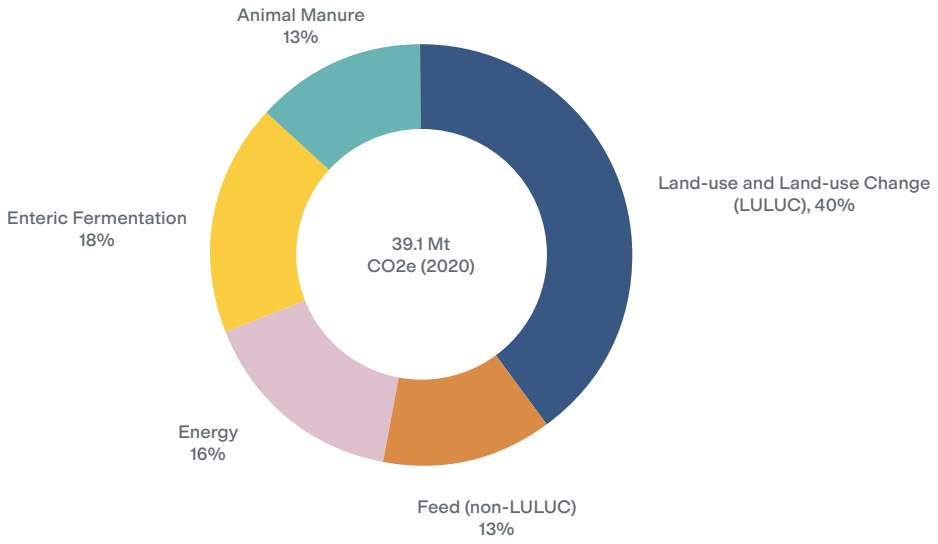


Source: FAO-GLEAM

Enteric fermentation is the biggest source of livestock emissions (45.4%), followed by feed production (22.4%),[43] then manure (12.8%)[44] among others, as per figure 20. The large share of enteric fermentation emissions is likely why methane reduction measures have garnered so much attention of late. However, the skew towards enteric fermentation is driven by production of ruminants, particularly beef and dairy cattle, which is distinct from Thailand's profile of majority monogastric meat and seafood production and a much smaller proportion of beef production.

Hence, we reclassified the various sources into broader categories: land-use and land-use change (LULUC), feed production (excluding LULUC), energy usage, enteric fermentation, animal manure, then we estimated how GHG emissions for Thailand's meat and seafood production are distributed across these categories as shown in Figure 21.

Figure 21: GHG emissions from Thailand's meat and seafood production, by source.



Source: FAO-GLEAM, ARE analysis

[43] Sum of 12.3% in CO2, 9.76% in NO2, 0.321% in CH4
[44] Sum of 4.99% in CO2 and 7.83% in CH4

This breakdown reflects the dominance of poultry and pork production in Thailand, such that LULUC, which includes deforestation for feed production, agricultural burning, and pasture expansion, is the largest source of overall emissions (40%). Conversely, enteric fermentation occupies just 18% of the total.

An understanding of the emissions sources allows for the various mitigation measures to be prioritised. For example, tackling LULUC including avoiding deforestation, the largest emissions source, should be of top priority, while methane reduction, even if successfully implemented, would have a smaller impact on total GHG emissions proportionate to its contribution.

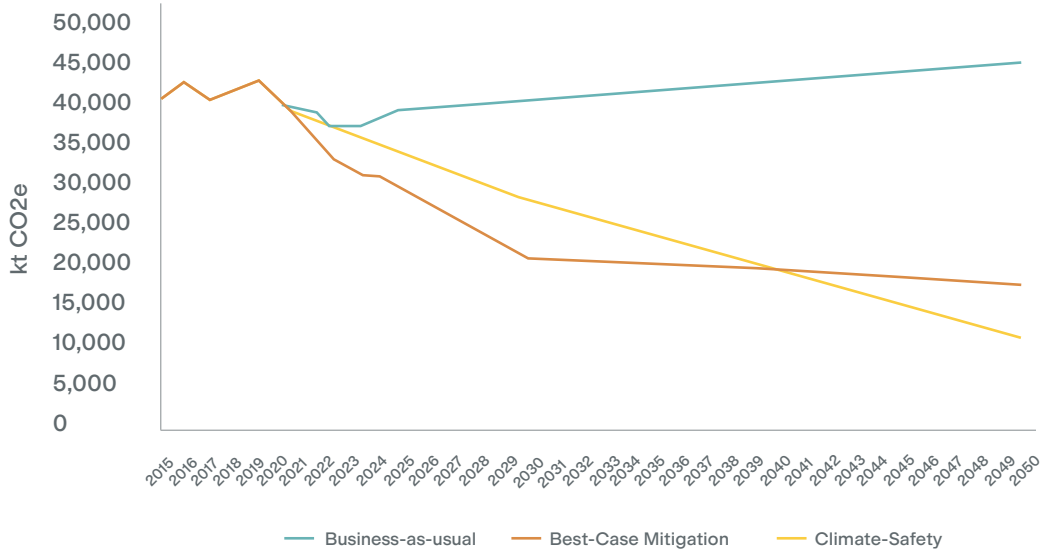
The question then is, which mitigation measures and to what extent would be required for Thailand's meat and seafood emissions to possibly go below the climate-safety threshold level as defined earlier?

To answer this, we estimated the GHG emissions in a best-case mitigation (BCM) scenario. This scenario incorporates the effect of various mitigation measures (Figure 21) on total GHG emissions, with consideration of Thailand's specific profile. The various theoretical mitigation measures are as below in Figure 22 and the application is depicted in Figure 23 against a climate-safe threshold.

Figure 22: Theoretical mitigation measures for a Best-Case Mitigation scenario.

Zero-Deforestation and Land-Use Change Target	2030
100% Clean Energy Target	2060
Enteric Fermentation Mitigation (% Reduction by 2050)	30%
Manure Emissions Mitigation (% Reduction by 2050)	30%
Feed Emissions Mitigation (% Reduction by 2050)	30%
Food Waste Reduction (% Reduction by 2030)	20%
% reduction targets are in terms of intensity per kg product and uses 2020 as the base-year	

Figure 23: Projected GHG emissions from Thailand's meat and seafood production in BAU and BCM scenarios, and the threshold for climate-safety.



Source: ARE analysis

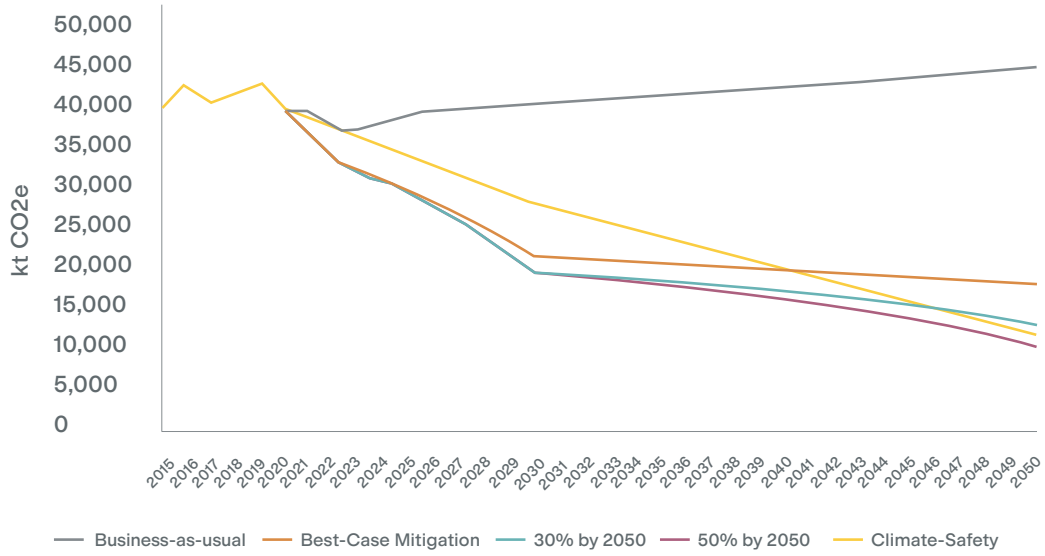
In a theoretical scenario as shown in figure 23 with these mitigation measures completely incorporated, the GHG emissions from meat and seafood production would be 17.3 Mt CO2e in 2050, significantly lower than the 44.9 Mt CO2e expected in the BAU scenario, but still substantially higher than the climate-safety threshold after 2040.

The reduction in GHG emissions is steepest between 2020 and 2030 due to the elimination of emissions from theoretically avoiding all deforestation and land-use change in the supply chain by 2030. Total GHG emissions are well below the climate-safety threshold in this period and up to 2040, but the additional mitigation measures are not significant enough to deliver the further mitigation required after 2040.

Plant-Based Diversification

Results show that plant-based proteins are required to achieve further emissions reductions to meet climate-safety, in addition to all the theoretical mitigation measures listed above. If we make the same assumptions for animal production and plant-based proteins: rate of clean energy adoption, elimination of deforestation and land-use change in the supply chain, and modest improvements in crop cultivation efficiencies, plant-based products are ultimately less emissions-intensive than any animal products (Figure 24).

Figure 24: Projected GHG emissions from Thailand's meat and seafood production in plant-based diversification scenarios, and the threshold for climate-safety (2020 to 2050). The projected emission in 2050 under the 50% plant-based scenario is 9.35 Mt CO2e, which is lower than BAU emission by 35.5 Mt CO2e.



Source: ARE analysis

Projections for the two plant-based diversification scenarios show further reduced GHG emissions that remain below the climate-safety threshold even after 2040. Total GHG emissions in the 30% by 2050 scenario eventually exceeds the climate-safety threshold in 2048, whereas the 50% by 2050 scenario shows that the climate-safety threshold remains unbreeched through 2050. Enabling a 50% scenario can enable a climate-safe protein system.

Discussion

The second Nationally Determined Contribution (NDC) submitted by Thailand in 2022 covers agriculture among key focus sectors and includes an unconditional emissions reduction target of 30% and a conditional target of 40% by 2030 as compared to the BAU scenario.[45] Mitigation of agricultural emissions in Thailand goes beyond mitigation of rice emissions. This will become increasingly necessary as meat and seafood production (and emissions) are projected to continue growing with regional and global demand, while challenged by physical climate impacts.

Enabling meaningful mitigation of emissions from meat and seafood production requires a multi-faceted approach that considers local supply side characteristics. While acknowledging the various supply side mitigation measures available, it is crucial to prioritize them

[45] https://unfccc.int/sites/default/files/NDC/2022-11/Thailand%202nd%20Updated%20NDC.pdf

based on their potential impact. Eliminating deforestation and land-use change in the supply chain must be a top priority. Tackling these emissions sources would simultaneously bring about benefits in lower particulate matter (PM2.5) pollution and reduce the rate of land degradation.

Adopting clean energy, reducing methane emissions in manure and enteric fermentation, and minimizing food waste are important steps. In addition to these priority mitigation measures, incorporating plant-based diversification on a large-scale such as in the 50% by 2050 scenario is also essential to achieve a climate safe protein system for Thailand and global decarbonisation. As previously mentioned, key plant-based protein crops can also enable yield and Thai farmer household resilience in the face of climate change, along with other benefits.

An essential enabler of supply side change is a demand side approach that emphasises healthy and sustainable food, with nutritional policies that help reduce excessive meat and seafood consumption and increase plant-based protein in diets. This is consistent with a growing body of science (summarised in a seminal EAT-Lancet Commission report) that demonstrates globally that demand side changes are necessary, as changes on the supply side alone will not enable us to meet the Paris Climate Goals.[46] As of 2022, Thailand's per capita consumption of overall meat and seafood is far higher than the scientific targets recommended by EAT-Lancet for healthy and sustainable diets.[47]

[46] https://eatforum.org/content/uploads/2019/07/EAT-Lancet_Commission_Summary_Report.pdf
[47] See annex for the scientific targets provided by EAT-Lancet

ECONOMIC ACTIVITY & OUTPUTS

Photo: Engin Akyurt

Thailand has long established itself as a leading producer of agricultural goods, earning a well-deserved reputation for its diverse and robust agricultural sector. The country's fertile land, favourable climate, and extensive network of farmers enabled it to produce a wide range of agricultural commodities that are desirable both domestically and internationally.

Poultry, shrimp, and tuna hold prominent positions within the top ten food exports of highest value. These products not only contribute significantly to the nation's economy and jobs, but also play a crucial role in Thailand's export portfolio. Success in these sectors highlights the country's expertise and efficiency in producing these agricultural goods.

Despite its strong agricultural foundation, Thailand has the potential to further enhance the value of its domestic production and exports by focusing on creating more value with domestically produced goods and services. This approach is especially crucial in the context of global sustainability trends and Thailand’s increasing reliance on imported raw materials for animal feed. Thailand has the potential to strengthen its position in the global market, but also ensure the long-term sustainability of its agricultural, protein-related, and rural jobs.

In a 50% plant-based scenario,
Thailand could add more than

1.15million jobs

demonstrating a positive contribution
to Thailand's employment and rural population.

Job creation and net jobs

30% of Thailand's workforce, or 12.7 million workers, are employed in agriculture. 12% of the agricultural workforce, or 1.4 million workers, are involved in animal production through husbandry and slaughter, not including those who produce crops for animal feed. As per global and local trends reported by the Thai Office of National Statistics, we employed a rate of natural attrition, driven by rural-urban migration and increasingly industrialised production systems, in our projections for the number of animal husbandry jobs in the BAU scenario. Aside from this natural attrition rate, the number of husbandry jobs is expected to follow a directly proportional relationship to the level of animal production.

The 30% plant-protein scenario does not project a decrease in the level of animal production from 2020 so we do not expect a loss of animal husbandry jobs, so plant-based protein production (and jobs) is mostly additional to the current animal production sector. If Thailand can scale up non-GMO food-grade soy production as raw materials for the additional plant-based protein production, we projected that by 2050 there could be an additional 1,230,645 jobs created for producing and processing of the edible soy.

In a 50% plant-based protein scenario, we project that natural attrition coupled with a 28% reduction in animal meat and seafood production would lead to the loss of 903,159 jobs in the animal husbandry sector. However, we found that 2,057,443 new jobs related to production of food-grade soybeans and plant-based protein production could be created. Net job creation would be 1,154,284 in a 50% scenario, demonstrating a positive contribution to Thailand's employment and rural population. While this is based mostly on smallholder soy cropping, this figure could be somewhat reduced if an increasing proportion of such soy is industrially produced by corporates.

Aside from workers directly involved in animal husbandry, we acknowledge a concern that the livelihoods of Thai workers involved in the production of maize for animal feed would be threatened. However, in a scenario of lower demand for animal feed crops, we expect that the industry would opt to first cut out cereal imports and continue sourcing from local maize producers. Since domestic maize production currently accounts for only 60% of Thailand's demand for cereals in animal feed production, the 28% reduction in animal production within the 50% plant-based scenario would only reduce the level of maize imports without hurting domestic maize production and jobs.

For these plant-based projections, we refer to the cropping of food-grade edible soy only, as this is currently the most prevalent form of plant-based protein produced in Thailand, and the most cost-effective of all plant-based proteins by weight of protein to date.[48] We also note this soy is usually not derived from deforestation-linked origins, as it is preferred as non-GMO soy. We calculated that Thailand could produce all this additional soy for human consumption, involving some replacement or transitional cropping and intercropping. In other words, the 50% scenario not only creates many more jobs, but also enables greater self-sufficiency for raw materials, and less reliance on animal feed imports. This becomes critical as demonstrated in the next sections.

Value of Exports and Net Exports

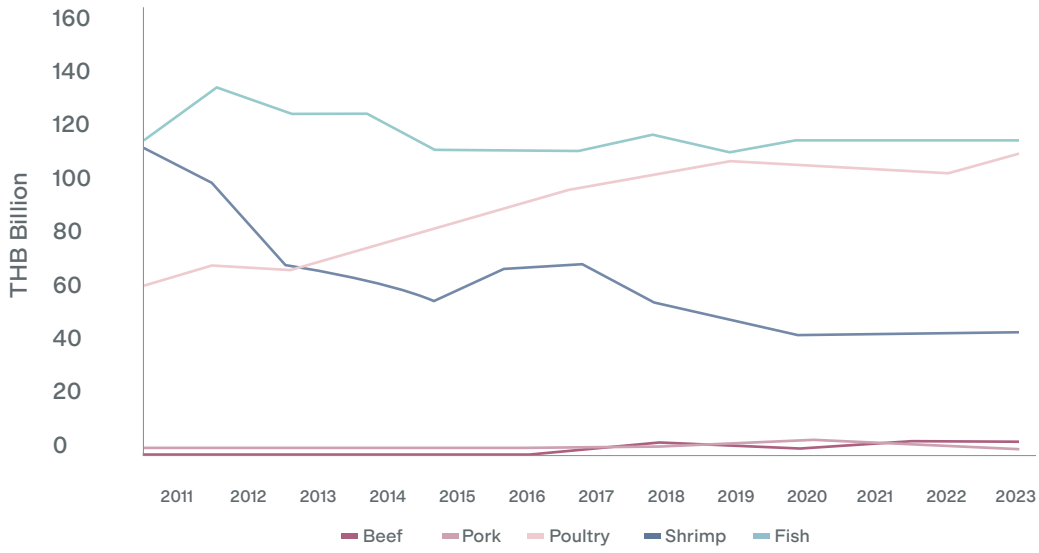
The Thai Office of Agricultural Economics (OAE) publishes monthly statistics on the quantity and value of key exports. As mentioned earlier and illustrated in figure 25 below, the key exports are poultry (meat), shrimp, and fish.[49] Fish exports take the top position with THB112 billion, closely followed by poultry (THB 104 billion), then shrimp (THB 43 billion). The value of beef and pork exports are relatively small compared to these commodities and do not exceed THB5 billion in any year within this timeframe.

The ongoing trends for these three commodities vary greatly. The value of fish exports, mostly wild caught, are stable over time, while the value of poultry exports exhibits rapid growth, and the value of shrimp exports is on the decline. These trends are generally congruent with the export quantity of each commodity and not determined solely by price fluctuations.

[48] https://www.ocbc.com/iwov-resources/sg/ocbc/gbc/pdf/sustainability/alternative%20protein_27%20jun%202022.pdf

[49] Includes both farmed and wild caught fish, as aggregated by OAE.

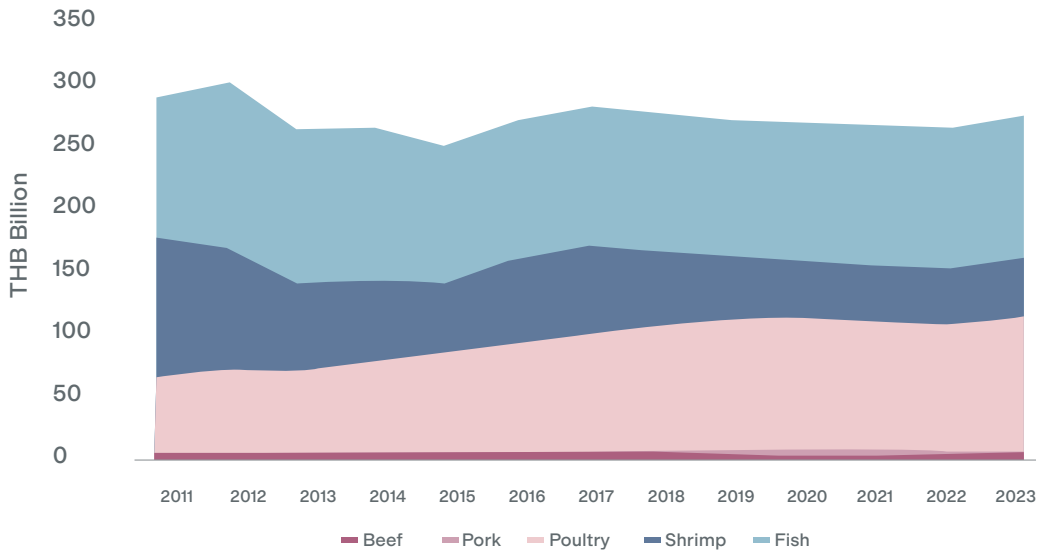
Figure 25: Value of Thailand's meat and seafood exports, by protein type (2011 to 2023).



Source: OAE, ARE analysis

Figure 26 shows that the value of overall meat and seafood exports have been stable above THB250 billion despite significant changes in the makeup of the export profile.

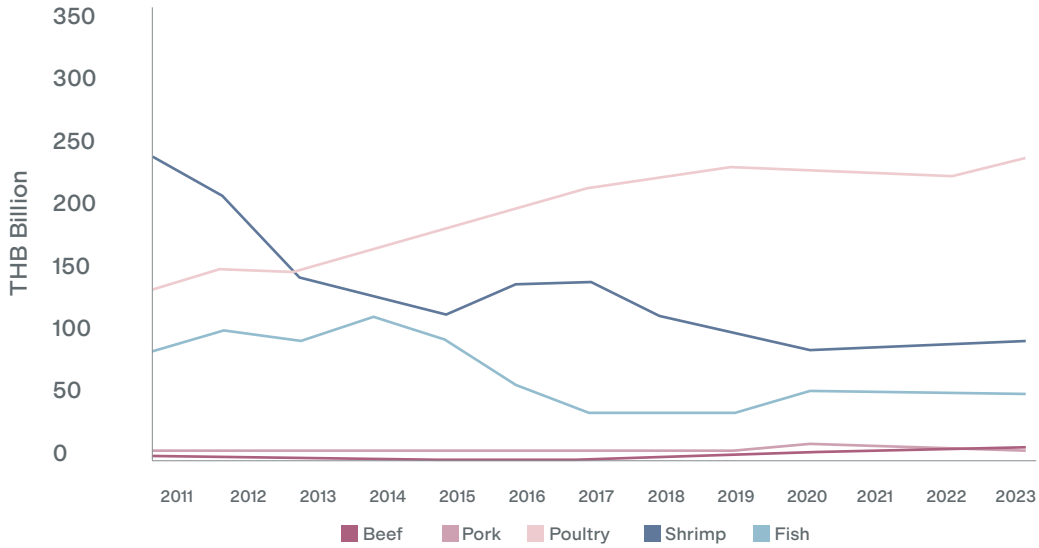
Figure 26: Value of Thailand's meat and seafood exports, by protein type (2011 to 2023).



Source: OAE, ARE analysis

However, exports are only one component of value added. We determined the value of net exports by deducting the value of imports from the export values, as per Figures 27 and 28.

Figure 27: Value of Thailand's meat and seafood net exports, by protein type (2011 to 2023).

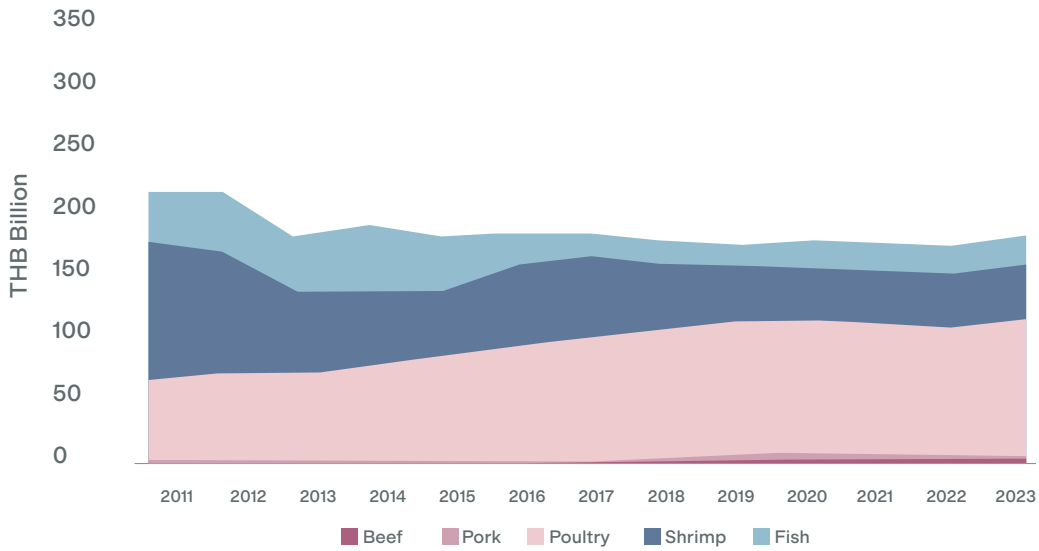


Source: OAE, ARE analysis

There is a clear distinction between the value of net exports and the previously shown value of exports, that is the contribution of fish to net export value had dropped to the lowest among the top three export commodities and barely a fifth of the export value, as shown in Figure 25.

This again shows the reliance on imports of wild caught fish as local fishery yields decline, but it is also a result of Thai residents' increasing preference for imports of freshwater fish that is more expensive than its wild caught exports.

Figure 28: Total value of Thailand's meat and seafood net exports, by protein type (2011 to 2023).



Source: OAE, ARE analysis

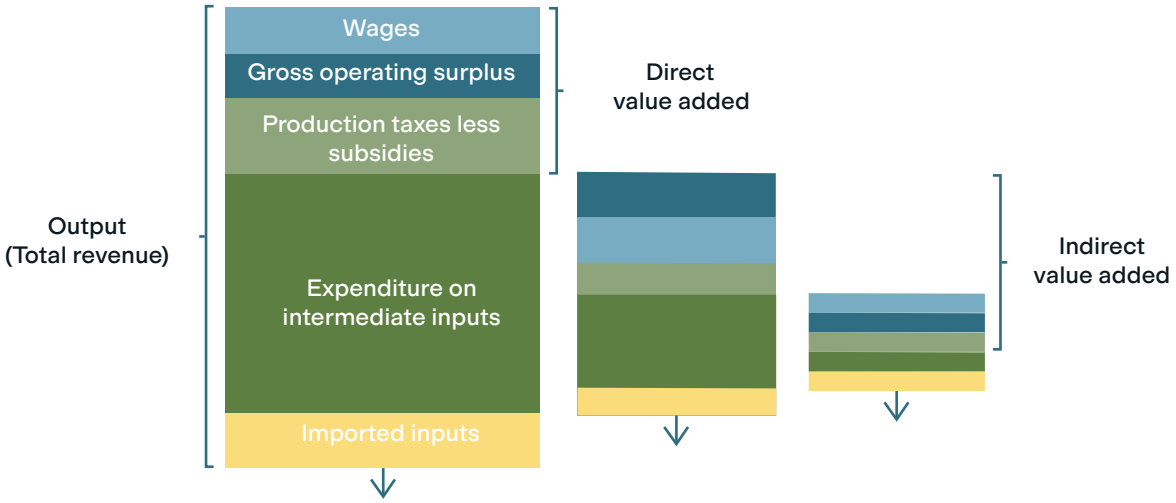
Figure 28 shows that the value of meat and seafood net exports are significantly lower, stabilising in 2016 at around THB175 billion, displaying a gradual downward trend from 2012.

Gross Value Added (GVA)

GVA is estimated to determine the economic contribution of the Thai meat and seafood sector in the BAU and plant-based diversification scenarios. We used the value-added approach to compute GVA and included both direct and indirect value-added in the production process.

To briefly explain the value-added approach: we begin from the perspective of the processed food manufacturer, the direct value-added is the value of the processed meat and seafood products minus the cost of intermediate inputs (mainly raw meat and seafood) used. Within these intermediate inputs, the value of intermediate inputs that were locally sourced becomes the production output and value earned by that local supplier (e.g. a Thai poultry producer). The direct value-added by the poultry producer, as defined by the value of poultry produced minus the value lost from Thailand of imported inputs (e.g. animal feed), is the indirect value-added of the meat and seafood sector. This process is iterated multiple times through the animal feed supplier, feed crop producer etc. The GVA of the meat and seafood sector is the summation of the direct and indirect value-added throughout these stages. We did not include side stream industries and their value such as pet food, leather and related byproducts, as these industries are not the primary driver of the meat and seafood sectors. However, we do mention the significant and growing Thai pet food industry in our discussion.

Figure 29: Definition of GVA as direct value-added and indirect value-added.



Source: https://www.beefcentral.com/wp-content/uploads/2018/10/B.FLT_.8011_Final_Report.pdf

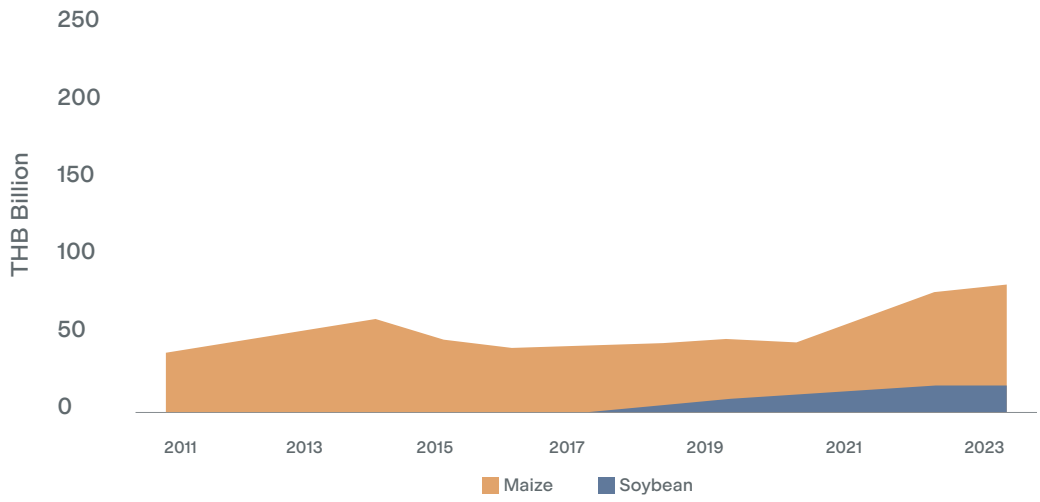
GVA can also be defined by the total value of meat and seafood, or plant-protein products consumed and exported minus the value of imported inputs throughout the value chain. We estimate the total value of meat and seafood products using the previously projected quantities and price assumptions, but it is not feasible to estimate the value of all imported inputs used throughout the value chain.

In our analysis, we focused on the two major inputs that could be imported, 1) raw meat and seafood and 2) crops used for animal feed production. The value of raw meat and seafood imports is illustrated in the previous section on value of exports and net exports. In the next section, we present our analysis for the projections for the value of imported crops used for animal feed production.

Animal Feed Raw Materials Imports

Thailand's reliance on imports of maize, soybean, and other crops was mentioned in the section on land use. Despite its sizeable domestic maize production, Thailand relaxed its import restriction on maize to meet the growing demand for animal production and related feed materials. Figure 30 shows the historical trends in these imports. The value of maize imports grew gradually from 2019 and reached THB15 billion in 2023. The value of soybean meal imports (primarily from Brazil) has always been significant at around THB40 billion. It spiked in recent years due to the convergence of greater animal production and higher soybean prices, reaching THB 62 billion in 2023.[50]

Figure 30: Value of Thailand's maize and soybean meal imports for animal feed (2011 to 2023).



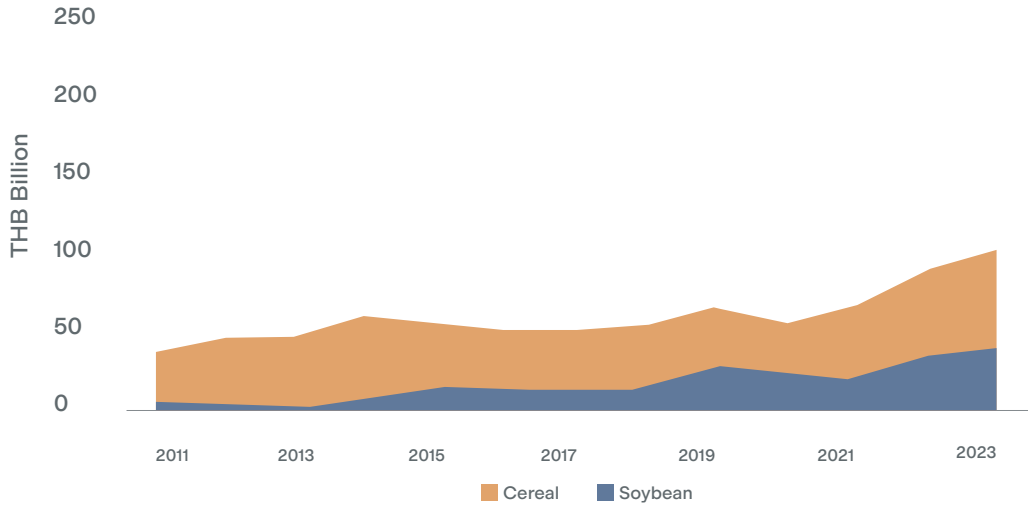
Source: OAE, ARE analysis

[50] Please note that "Soybean Meal" by OAE does not include soybean or soybean oil for human consumption.

Our analysis sought to further refine the estimated value of these feed imports. Although maize imports were recorded within OAE's statistics, the imports of other cereals were not provided. Figure 31 projects the value of cereal and soybean meal imports. The import price of maize was used to estimate the value of these other cereals[51] since they contain similar nutritional values and are substitutes for each other.

Increased demand and production of animal proteins increases Thailand's reliance on importing more raw animal feed materials. Projecting an increase in the quantity of raw material imports follows from our previous analysis which has elaborated on the various limitations of further Thai intensification of crop production.

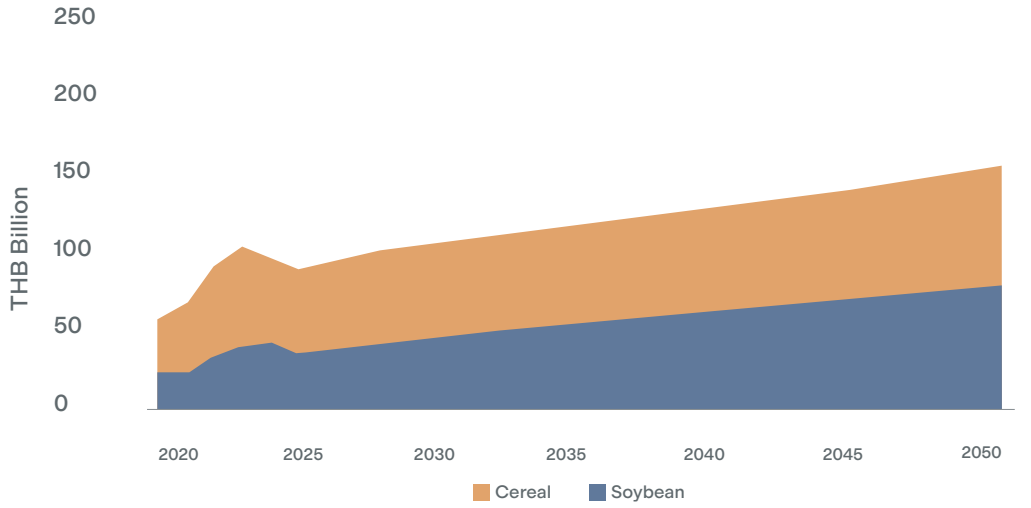
Figure 31: Value of Thailand's cereal and soybean meal imports for animal feed (2011 to 2023).



Source: OAE, ARE analysis

Purchasing prices for these crops were not assumed to continue rising in terms of real dollars, even though there is good reason to believe they would, especially in the face of limited yields due to physical impacts of climate change. Instead, 5-year average prices from 2019-2023 were used and assumed as constant through 2020 within the projected timeframe. The projected values for these feed crop imports are shown in Figure 32.

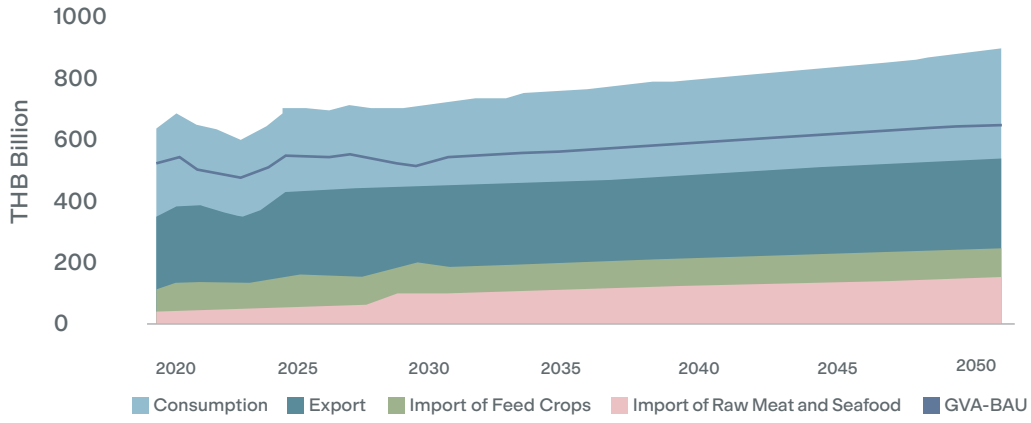
Figure 32: Projected value of Thailand's cereal and soybean meal imports for animal feed (2020-2050).



Source: OAE, ARE analysis

Subtracting the value of these two import categories from the value of consumption and exports, Figure 33 estimates the historical and projected GVA of the Thai and meat and seafood sector.

Figure 33: Estimated and projected GVA of Thailand's meat and seafood sector (2011-2050).

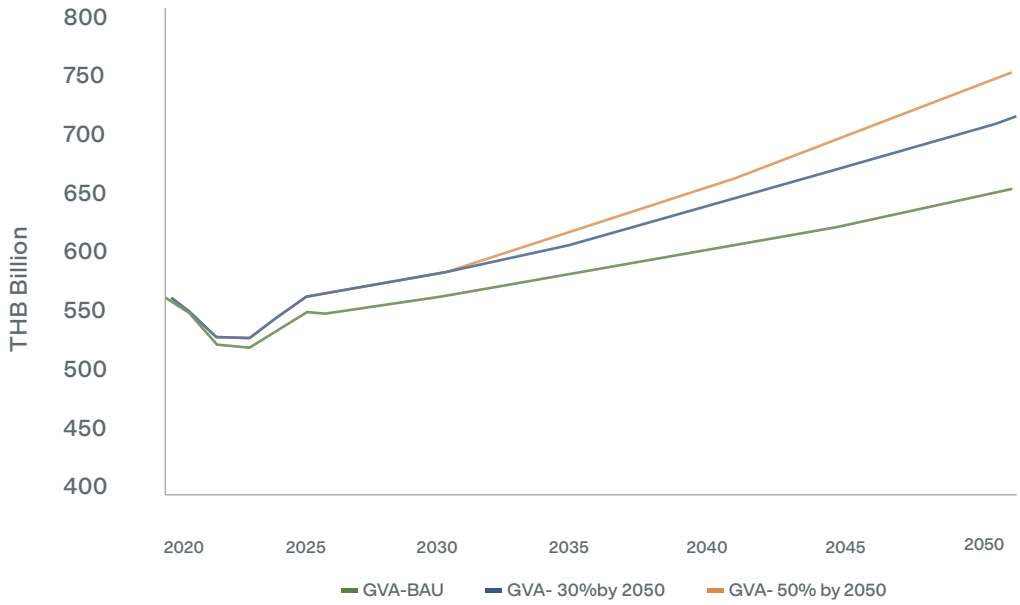


Source: ARE analysis

Plant-based Diversification

We estimated the GVA of the meat and seafood sector in the plant-based diversification scenarios and estimated that they will increase through 2050, but at a greater rate compared to the BAU scenario (Figure 34).

Figure 34: Projected GVA Thailand's meat and seafood sector in the BAU and plant-based diversification scenarios.



Source: ARE analysis

The animal and plant-based protein sectors do not operate on a level playing field at present, with government subsidies or structural support implicitly enabling the Thai animal protein sector. Subsidies and / or government investment do not yet exist for the plant-protein sector in Thailand. In the 50% scenario compared to the BAU scenario as in Figure 34, Thai government plus private investment could yield an additional cumulative GVA (2020 to 2050) from 50% plant-proteins of around THB1.3trillion or USD36.8 billion. This analysis underlines potential investment opportunity in enabling the further development and scaling of plant-based proteins.

It is important to note that we do not rely on assumptions that plant-based products can be sold at a premium through the long-term. Previous research by ARE[52] found that plant-based products from Bangkok sell at around a 22% premium compared to animal products. Our modelling incorporated this price premium from 2020 adjusting it to decline at a constant rate until reaching price parity in 2030. From 2030, the projections do not assume that plant-based products will command a higher price point or higher output value, but GVA rises due to a lower reliance on imports of raw materials.

[52] https://asiareengage.com/asia-supermarket-scorecard-thailand/

Discussion

The above analysis shows a just transition to 50% protein diversification with consultation, supportive policy and capacity building farmers and others in the plant-protein and cropping industries, could by 2050 create over 2million jobs for smallholders, with a reduction of less than 1 million jobs in the animal husbandry/ slaughter etc sector.

Overall, by 2050 there could be a net job creation of over 1.15million jobs with a 50% plant-based protein scenario, particularly serving or consolidating smallholder farmers for sustainable livelihoods. This would be an optimal situation involving mostly smallholder job creation, with reduced jobs depending on the proportion of industrially cropped soy for human consumption. Our findings are broadly consistent with other global and regional studies, such as an assessment of the Latin America region finding 15million net jobs are created as part of a broader study of 2030 towards a transition to net zero.[53] Another more conservative global protein diversity study projected 2.2 million net direct job growth by 2035 and 2.3 million by 2050.[54]

The value of increasing growth of the animal protein sector in a BAU scenario is undermined by the increasing reliance on imported feed materials, namely maize and soybean, now and into the future. We do acknowledge that the animal meat and seafood industry contributes significantly to exports by the Thai pet food industry. Net export value of pet food, after deducting the value of pet food imports and non-meat pet food exports, was estimated at THB71.4 billion in 2022 and more than doubled from 2018. The growth of this industry has been tremendous, but it relies on the existing animal production drivers and supply chains and faces the same sustainability challenges mentioned throughout the report. While creation of added value through side streams should be encouraged, the potential growth of this industry should be re-evaluated if it relies on increasing production and imports of animal proteins. Meanwhile, we see even Thailand's major sugar producer collaborating with the plant-based meat industry.[55]

[53] https://www.ilo.org/publications/jobs-net-zero-emissions-future-latin-america-and-caribbean
[54] https://www.climateworks.org/wp-content/uploads/2021/11/GINAs-Protein-Diversity.pdf
[55] https://aseannow.com/topic/1325618-plant-based-meat-popularity-fuels-new-ventures-in-thailand/

Photo: Mark Stebnicki

However, the cost structure of plant-based products relies less on the raw material input over time and provides greater opportunities for Thailand to value-add through its advanced processing capabilities and its established reputation as a reliable food processor. In addition, the Sustainable Rice Platform and EU Organic requirements for intercropping (e.g. rice, other cash crops) with legumes for nitrogen fixation and soil fertility, offers significant value potential for raw material crops such as soy, peas or mung beans for plant-based protein production in Thailand.

The current plant-protein to meat/seafood price inequality and policy framework does not enable the full potential demand and scaling of plant proteins yet in Thailand, which depends on a multitude of factors from technological breakthroughs to policy shifts. This is precisely why the government should create enabling policy and investment, supporting or collaborating with plant-based and wider food industry to enhance Thailand's comparative advantage while reducing negative impacts of its current animal protein reliant food system.

CONCLUSION

Photo: Quang Nguyen

In the face of growing demand and physical climate risks, continuing with the existing model of using animal production to satisfy meat and seafood demand does not offer prospects for alleviation of pressure or value adding opportunities from an already overburdened system.

Our projections for land-use and land-use change including that linked to deforestation and biodiversity loss, plus GHG emissions in the three scenarios, show that these impacts are only set to worsen if BAU continues without wide-scale diversification with plant-based proteins.

Key findings show that business as usual will seriously accelerate negative impacts and resource depletion, that the 30% plant-based protein production scenario by 2050 will mostly be for additional protein demand to 2050 and will not alleviate most negative impacts adequately or align with climate-safety. Instead support for scaling up plant-based protein production towards 50% of total meat and seafood production, as shown in the 50% by 2050 scenario is necessary for the following reasons:

- The BAU scenario shows additional land of 1.87 million hectares is required to support meat and seafood production in 2050 if the system relies on animal proteins. A moderate level of plant-based diversification in the 30% by 2050 scenario would still require an additional 576 thousand hectares of land in 2050. In contrast, the 50% by 2050 scenario shows that 293 thousand hectares of land can be saved and rehabilitated through significant plant-based diversification.

- Under the BAU scenario, 44.9 Mt CO2e of GHG emissions from meat and seafood production will be produced annually by 2050, over four times of the climate-safety threshold. Mitigation measures through avoiding deforestation, using clean energy, methane and manure management, and reducing food waste, are necessary but not sufficient. Achieving 50% plant-based protein diversification is crucial to reaching the climate-safety threshold.

- In the 50% scenario compared to the BAU scenario, Thai government plus private investment could yield an additional cumulative GVA (2020 to 2050) from 50% plant-proteins of around THB1.3 trillion or USD36.8 billion. This could also create over 1.15 million net Thai jobs in this sector. This analysis underlines the potential policy imperative and investment opportunity, enabling the further development and scaling of plant-based proteins.

Furthermore, the land-climate dynamics act in a feedback loop which continuously accelerates the rate of climate and land changes, as well as decreasing crop yields and impacts on animal production. Crop burning also leads to increased soil degradation. Without the protective cover of crop residues, the soil is more exposed to wind and water and gets eroded.[56] Soil degradation and loss in land fertility eventually leads to further reliance on fertilizer inputs which is ultimately unsustainable and further polluting,[57] and eventually further deforestation and land clearing is required to maintain crop yields.

Deforestation is more than a consequence of but also a driver of reduced crop yields.[58] Loss of forest cover that is crucial in regulating the water cycle had induced changes in rainfall patterns that negatively impacted soybean and maize yields in Brazil. Deforestation and land-use change is a key driver of global GHG emissions and especially so for Thailand's meat and seafood sector, as highlighted in the IPCC Special Report on Climate Change and Land.[59] Conversely, a warmer climate will aggravate the degradation processes through floods and more frequent droughts.[60]

[56] https://pubmed.ncbi.nlm.nih.gov/35462257/
[57] https://www.sciencedirect.com/science/article/abs/pii/B9780081030172000027
[58] https://www.sciencedirect.com/science/article/pii/S0304380023002636
[59] https://www.ipcc.ch/srccl/
[60] https://www.nasa.gov/centers-and-facilities/goddard/warming-makes-droughts-extreme-wet-events-more-frequent-intense/#:~:text=%E2%80%9CGlobal%20warming%20is%20going%20to,their%20impacts%2C%20and%20adapting.%E2%80%9D

Photo: Red Nguyen

Prompt yet strategic action is needed. Thailand is vulnerable to physical climate risks and ranks ninth among countries most affected by climate change.[61] The country has a strong imperative to mitigate and adapt to these changes. But the conventional mindset of ‘sustainable intensification’ and maximising the yield per unit of land needs to be replaced by one that considers re-balancing diets, supporting farmers, innovation, ecosystem conservation and regeneration to sustain long-term viability.

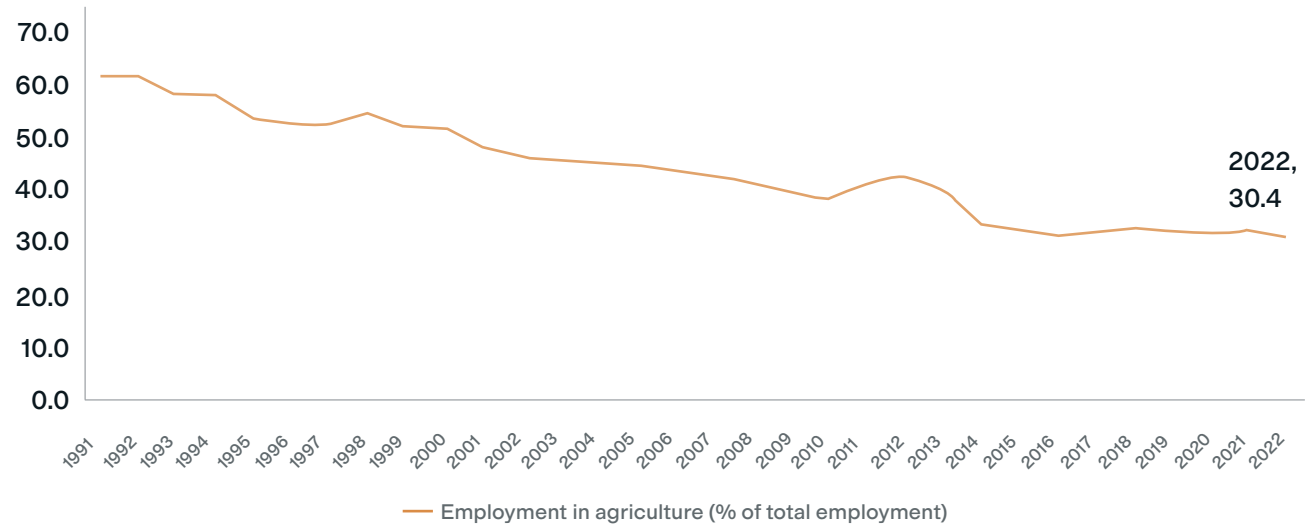
Thailand’s BCG (Bio-Circular-Green) economy model and its Future Food industry initiatives provide a robust framework for the development of plant-based proteins. The BCG model's emphasis on sustainability, efficient resource use, and reducing environmental impact aligns perfectly with the production of plant-based proteins, which have a far lower environmental footprint compared to animal-based proteins. The growing global demand for plant-based proteins presents significant economic opportunities[62] for the sector to simultaneously achieve objectives for smallholder enrichment, environmental restoration, and high value-added crop and protein production.

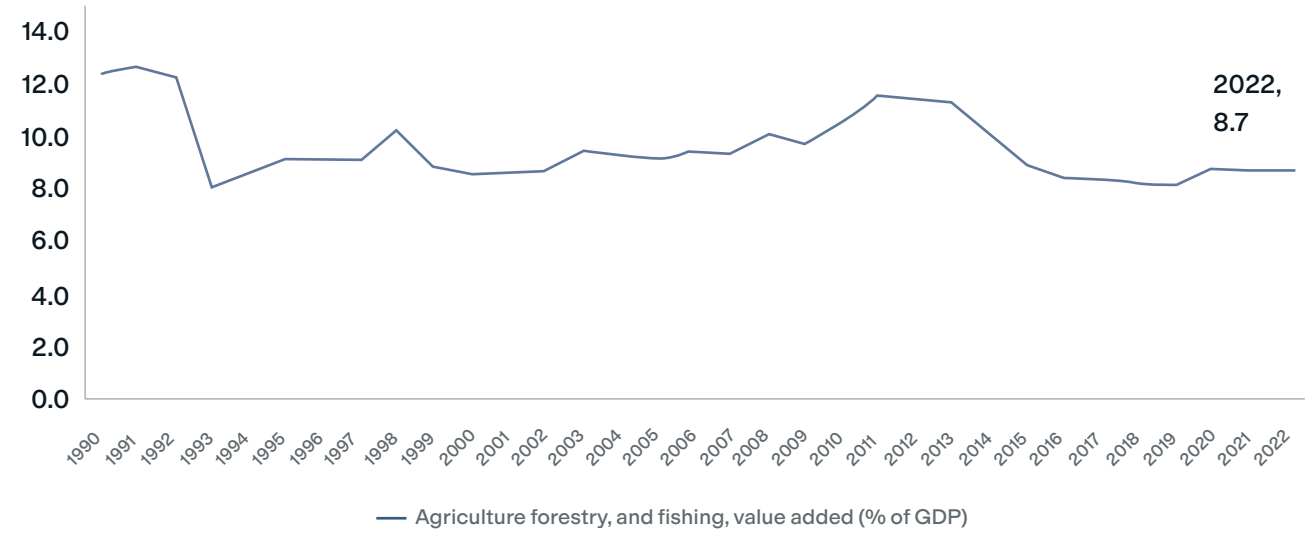
For decades, Thailand has harnessed its rich natural resources to play a pivotal role in delivering regional and global food security. As we look to the future, it is now time for the "Kitchen of the World" to remodel itself for the coming decades.

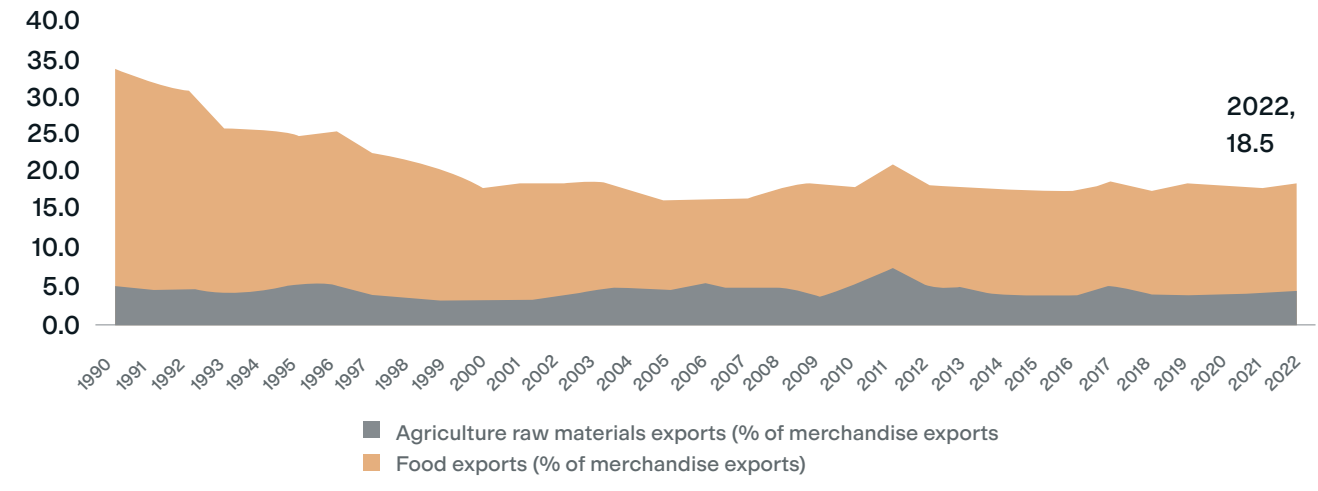
[61] https://germanwatch.org/sites/default/files/Global%20Climate%20Risk%20Index%202021_2.pdf
[62] https://www.bloomberg.com/company/press/plant-based-foods-market-to-hit-162-billion-in-next-decade-projects-bloomberg-intelligence/

APPENDIX

Past Agricultural Trends in Thailand, 1990-2022

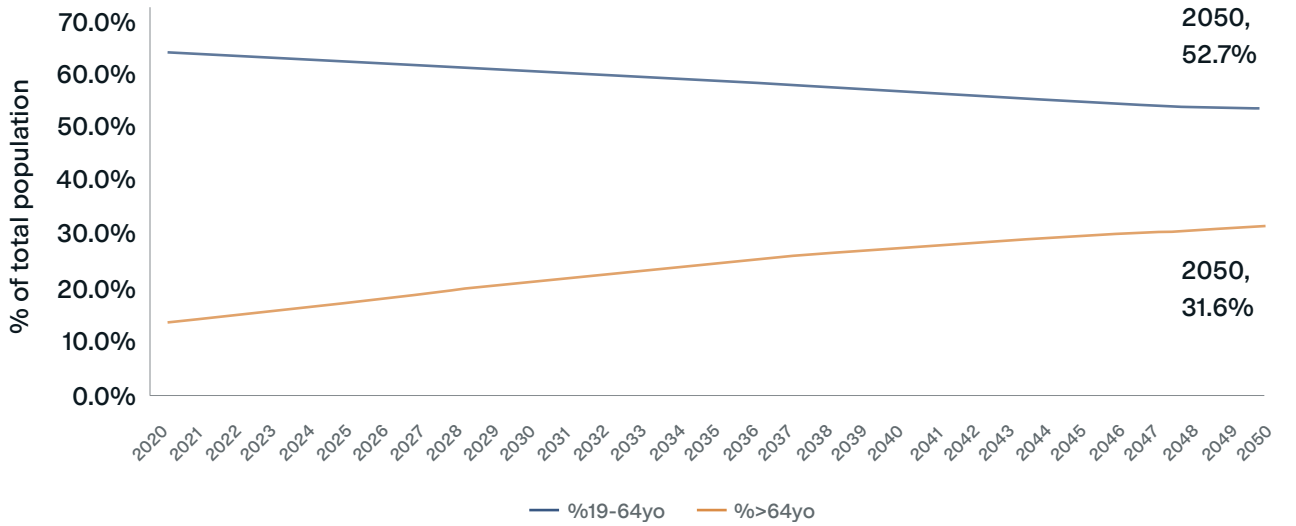


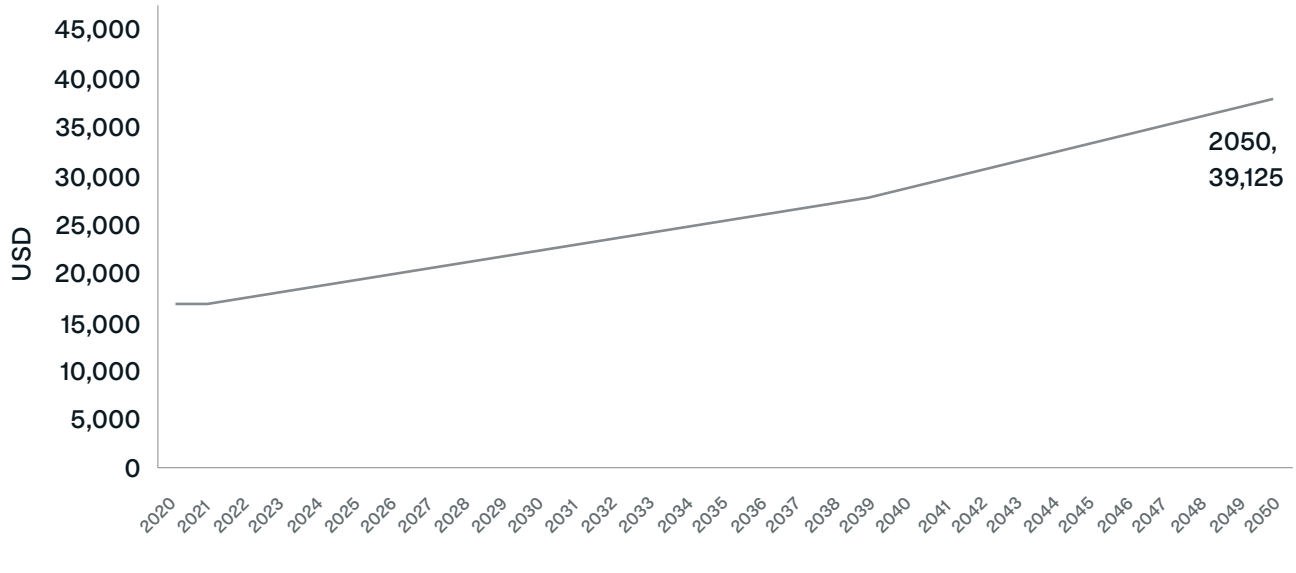


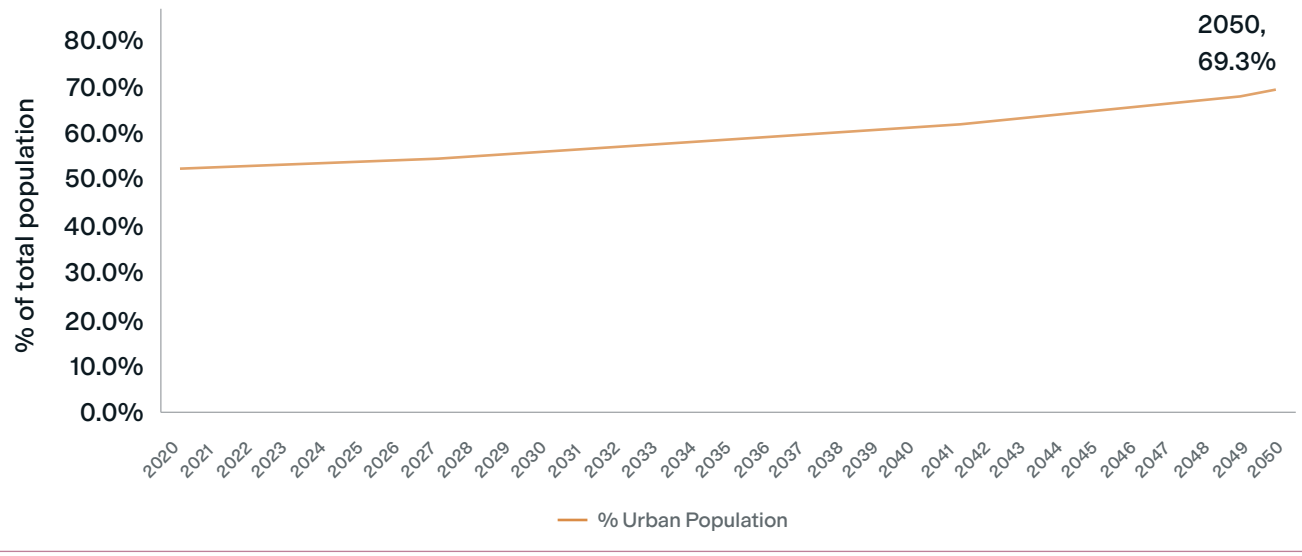


APPENDIX

Demographic Trends, 2020-2050







APPENDIX

Key Figures and Projections

All volumes below are expressed as dressed and bone-free, in units of thousand tonnes.

Production	1990	2000	2010	2020	2030	2040	2050
Beef	234	131	199	127	136	152	171
Pork	219	451	629	738	794	892	1,007
Poultry	562	1,044	1,242	1,978	2,227	2,538	2,905
Shrimp	150	263	420	311	324	332	337
Farmed Fish	78	162	215	197	274	341	398
Wildcaught Fish	891	1,016	606	551	474	407	350
Meat	1,015	1,626	2,070	**2,843**	3,157	3,582	4,083
Seafood	1,119	1,441	1,241	**1,059**	1,072	1,081	1,085
Meat & Seafood	2,134	3,066	3,311	**3,902**	4,229	4,663	5,168

Imports	1990	2000	2010	2020	2030	2040	2050
Beef	5	22	13	51	71	79	87
Pork	0	0	1	1	1	1	1
Poultry	2	1	2	2	2	2	2
Shrimp	7	16	18	20	22	24	27
Farmed Fish	2	14	37	92	198	289	368
Wildcaught Fish	200	270	657	758	651	560	481
Meat	7	23	16	**54**	74	81	90
Seafood	209	300	712	**869**	871	873	876
Meat & Seafood	216	323	728	**923**	945	955	966

Exports	1990	2000	2010	2020	2030	2040	2050
Beef	1	3	70	92	114	126	139
Pork	1	5	58	194	208	230	254
Poultry	100	189	263	573	712	826	959
Shrimp	86	199	343	125	138	152	168
Farmed Fish	3	4	43	36	149	245	328
Wildcaught Fish	398	528	905	802	689	593	510
Meat	102	198	391	859	1,034	1,182	1,352
Seafood	488	731	1,291	962	975	990	1,006
Meat & Seafood	589	928	1,682	1,821	2,009	2,172	2,357

Consumption	1990	2000	2010	2020	2030	2040	2050
Beef	237	150	142	86	93	105	119
Pork	218	446	572	545	587	663	754
Poultry	464	856	982	1,408	1,517	1,714	1,948
Shrimp	70	80	95	206	208	205	196
Farmed Fish	77	172	210	253	324	385	438
Wildcaught Fish	693	758	358	507	436	375	322
Meat	920	1,451	1,696	2,038	2,197	2,482	2,821
Seafood	841	1,010	662	966	968	964	956
Meat & Seafood	1,761	2,461	2,358	3,004	3,165	3,446	3,777

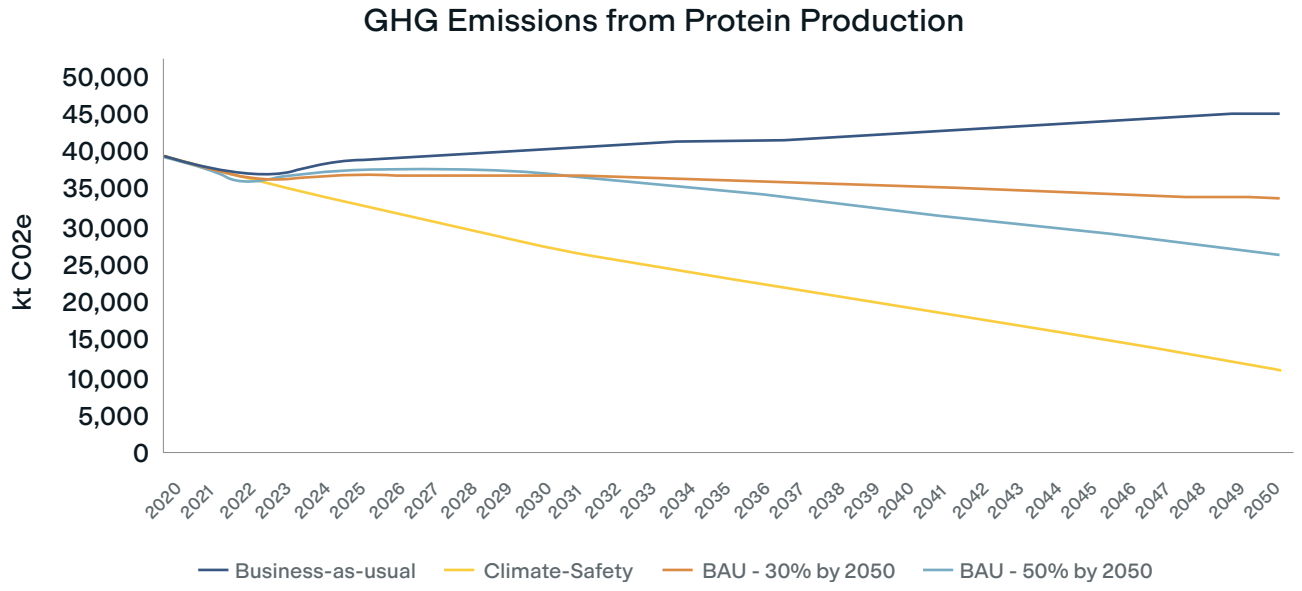
All volumes below are expressed as dressed and bone-free.

Consumption per capita (kg / year)	1990	2000	2010	2020	2030	2040	2050
Beef	4.3	2.4	2.1	1.2	1.3	1.5	1.8
Pork	4.0	7.1	8.4	7.6	8.1	9.4	11.1
Poultry	8.4	13.6	14.4	19.7	21.1	24.2	28.7
Shrimp	1.3	1.3	1.4	2.9	2.9	2.9	2.9
Farmed Fish	1.4	2.7	3.1	3.5	4.5	5.4	6.4
Wildcaught Fish	12.6	12.0	5.2	7.1	6.0	5.3	4.7
Meat	16.7	23.0	24.8	28.5	30.5	35.0	41.6
Seafood	15.2	16.0	9.7	13.5	13.4	13.6	14.1
Meat & Seafood	31.9	39.0	34.5	42.0	43.9	48.6	55.6

Net Exports (thousand tonnes)	1990	2000	2010	2020	2030	2040	2050
Beef	-4	-19	57	41	43	47	52
Pork	1	5	57	193	207	229	253
Poultry	98	188	260	571	710	824	957
Shrimp	80	183	325	105	116	128	141
Farmed Fish	1	-10	6	-56	-49	-44	-40
Wildcaught Fish	198	258	248	44	38	33	28
Meat	95	175	374	804	960	1,100	1,262
Seafood	278	430	579	93	104	116	130
Meat & Seafood	373	605	-953	898	1,064	1,217	1,391

Total Demand (thousand tonnes)	1990	2000	2010	2020	2030	2040	2050
Beef	238	153	212	178	207	231	258
Pork	219	451	630	739	795	893	1,008
Poultry	564	1,045	1,245	1,980	2,229	2,540	2,907
Shrimp	157	279	438	331	346	357	364
Farmed Fish	80	176	252	289	472	630	766
Wildcaught Fish	1,091	1,287	1,263	1,309	1,125	967	832
Meat	1,022	1,649	2,086	**2,897**	3,231	3,663	4,173
Seafood	1,329	1,741	1,953	**1,928**	1,943	1,954	1,961
Meat & Seafood	2,350	3,390	4,040	**4,825**	5,174	5,618	6,134

GHG emissions with plant-based diversification but without other mitigation measures



OECD-FAO Agricultural Outlook's forecast for soybean yields in USA and Brazil

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
USA	3.45	3.48	3.33	3.40	3.42	3.44	3.46	3.48	3.48	3.52	3.55
Brazil	3.47	3.03	3.51	3.54	3.49	3.51	3.53	3.56	3.56	3.61	3.64

Near-term SBTi's FLAG pathways – targets for annual reduction in emissions intensity

Commodity	% / year (2020-2030)
Beef	2.4
Pork	3.3
Chicken	3.9

EAT-Lancet's recommendations for meat and seafood consumption (as a maximum amount)

Meat / Seafood	grams / week
Red Meat (Beef, Pork, Lamb)	98
Poultry	203
Seafood	196

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